Final

Plan Formulation Appendix

Shasta Lake Water Resources Investigation, California

Prepared by:

United States Department of the Interior
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Abbreviations and Acronyms

2004 OCAP BA	Reclamation 2004 *Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan NMFS Biological Opinion*
2004 NMFS BA	NMFS 2004 *Long-Term CVP and SWP Operations Criteria and Plan Biological Assessment*
2005 USFWS BO	USFWS 2005 Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues
2008 Long-Term Operation BA	Reclamation 2008 *Biological Assessment on the Continued Long-Term Operations of the CVP and SWP*
2008 USFWS BO	USFWS 2008 *Formal ESA Consultation on the Proposed Coordinated Operations of the CVP and SWP*
2009 NMFS BO	NMFS 2009 *BO and Conference Opinion on the Long-Term Operations of the CVP and SWP*
AFS	anadromous fish survival
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BDCP	Bay-Delta Conservation Plan
BLM	Bureau of Land Management
BO	Biological Opinion
CA	California Aqueduct
CALFED	CALFED Bay-Delta Program
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
CO	combined objectives
CP	Comprehensive Plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento-San Joaquin Delta
DEIS	Draft Environmental Impact Statement
DHCCP	Delta Habitat Conservation and Conveyance Plan
DMC	Delta-Mendota Canal

DMC/CA	Delta Mendota Canal/California Aqueduct
DWR	California Department of Water Resources
EIS	Environmental Impact Statement
elevation xxx	elevation in feet above mean sea level
ESA	Federal Endangered Species Act
GIS	geographic information system
GWh	gigawatt-hour
I-5	Interstate 5
IDC	interest during construction
M&I	municipal and industrial
MAF	million acre-feet
MW	megawatt
NED	National Economic Development
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NODOS	North-of-the-Delta Offstream Storage
NRA	National Recreation Area
O&M	operations and maintenance
P&G	*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
PG&E	Pacific Gas and Electric Company
PMF	Probable Maximum Flood
RBPP	Red Bluff Pumping Plant
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
ROD	Record of Decision
RPA	reasonable and prudent alternative
SLWRI	Shasta Lake Water Resources Investigation
SRTTG	Sacramento River Temperature Task Group
STNF	Shasta-Trinity National Forest
SWP	State Water Project
State Water Board	State Water Resources Control Board
TCD	temperature control device
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USFS	U.S. Department of Agriculture, Forest Service
USFWS	U.S. Department of the Interior, Fish and Wildlife Service
WSR	water supply reliability

Chapter 1
Introduction

This appendix describes the iterative plan formulation and evaluation process for the Shasta Lake Water Resources Investigation (SLWRI) by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation), Mid-Pacific Region. This chapter defines planning objectives, constraints, and criteria. Subsequent chapters describe management measures, representative sets of concept plans, and development of comprehensive plans. Information presented in this appendix is used to support discussions in the Environmental Impact Statement (EIS).

Plan Formulation Process

Consistent with the National Environmental Policy Act (NEPA), the plan formulation process for Federal water resources studies is identified in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&G) (WRC 1983) and consists of the following deliberate and iterative steps:

- Identifying water resources problems, needs, and opportunities to be addressed, and developing planning objectives, constraints, and criteria.
- Inventorying and forecasting conditions likely to occur in the study area.
- Evaluating and comparing alternative plans.
- Selecting a plan for recommendation to decision makers for implementation or no action.

For the SLWRI, this iterative process was separated into multiple phases as illustrated in Figure 1-1 and described below:

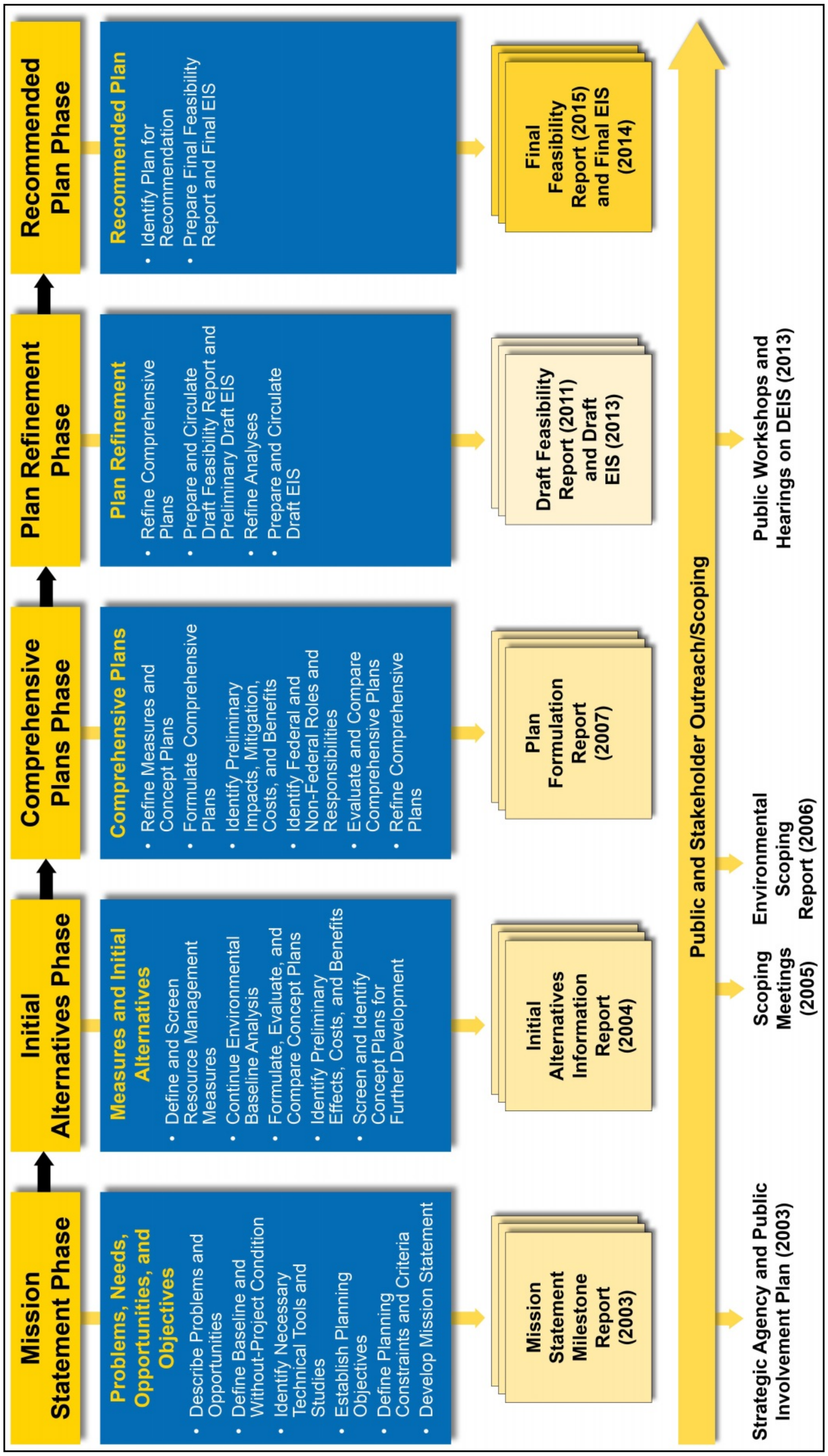


Figure 1-1. Plan Formulation Phases

- **Mission Statement Phase –** This study phase consisted of projecting without-project future conditions, defining resulting resource problems and needs, defining a specific set of planning objectives, and identifying constraints and criteria for addressing the planning objectives. The results of this phase of study were included in the 2003 *SLWRI Mission Statement Milestone Report* (Reclamation 2003a).

- **Initial Alternatives Phase –** This phase included developing a number of potential management measures, or project actions or features designed to address planning objectives. These measures were then used to formulate a set of plans that were conceptual in scope (concept plans). These initial plans were evaluated and compared to the planning objectives to identify the most suitable plans for further development. The results of this phase of study were included in the 2004 *SLWRI Initial Alternatives Information Report* (Reclamation 2004a).

- **Comprehensive Plans Phase –** The measures and concept plans carried forward were further refined and developed with more specificity to formulate comprehensive plans to address the planning objectives. These plans were then evaluated and compared. The results of this phase of the study were included in the 2007 *SLWRI Plan Formulation Report* (Reclamation 2007).

- **Plan Refinement Phase –** This phase focused on further refinement and iterative evaluation of the potential effects of the comprehensive plans. This phase included preparing and circulating a Draft Feasibility Report, which was completed in November 2011 and released to the public in February 2012, and Draft EIS (DEIS), which was released to the public in June 2013 for public review and comment.

- **Recommended Plan Phase –** This phase of the SLWRI planning process focuses on identifying a plan for recommendation and preparing and processing the Final Feasibility Report, to support a Federal decision, and the Final EIS.

Public and stakeholder outreach was performed concurrently with the above phases, as shown in Figure 1-1. Major reports include the *SLWRI Strategic Agency Public Involvement Plan*, published in 2003 (Reclamation), and the *SLWRI Environmental Scoping Report*, published in 2006 (Reclamation).

As shown in Figure 1-1, emphasis in these planning phases changes as the feasibility study proceeds. In the beginning, the emphasis is on defining problems, needs, and opportunities, and inventorying and forecasting conditions in the study area to help define a specific set of planning objectives. In time, however, emphasis shifts to defining management measures and ways of combining the most appropriate of these measures into concept plans. Later, emphasis shifts to formulating, evaluating, and comparing complete and comprehensive alternatives. Still later in the study, emphasis is on defining and describing a plan for recommendation and preparing a Feasibility Report. During each study phase, it is important to review and revise, if necessary, previous decisions and future study planning objectives.

CALFED Tiering

The 2000 CALFED Bay-Delta Program (CALFED) Programmatic Environmental Impact Statement/Environmental Impact Report (PEIS/R) Preferred Program Alternative and associated CALFED Programmatic Record of Decision (ROD) recommended five surface water storage projects to be pursued with project specific studies. These studies included Shasta Lake Enlargement, Los Vaqueros Reservoir Enlargement, Sites Reservoir, In-Delta Storage, and development of storage in the upper San Joaquin River Basin. As described in the CALFED Programmatic ROD:

> *For actions contained within the Preferred Program Alternative that are undertaken by a CALFED Agency or funded with money designated for meeting CALFED purposes, environmental review will tier from the [CALFED] Final Programmatic EIS/R.*

Accordingly, since the SLWRI is an action contained within the CALFED Preferred Program Alternative, this EIS tiers to the CALFED PEIS/R. The CALFED Programmatic ROD describes tiering as follows:

> *Whenever a broad environmental impact analysis has been prepared and a subsequent narrower analysis is then prepared on an action included within the entire program or policy, the subsequent analysis need only summarize the issues discussed in the broader analysis and incorporate discussions from the broader analysis by reference. This is known as tiering. Tiered documents focus on issues specific to the subsequent action and rely on the analysis of issues already decided in the broader programmatic review. Absent new information or substantially changed circumstances, documents tiering from the CALFED Final Programmatic EIS/R will not revisit the alternatives that were considered alongside CALFED's Preferred Program Alternative nor will they revisit alternatives that were rejected during CALFED's alternative development process.*

As discussed in more detail in the Section "Planning Constraints and Other Considerations," preliminary studies in support of the CALFED PEIS/R considered more than 50 surface water storage sites throughout California and recommended more detailed study of the five sites identified in the CALFED

Programmatic ROD (CALFED 2000a, 2000b, 2000c). Consistent with the above guidance in the CALFED Programmatic ROD, this EIS relies on evaluations and alternatives development and screening included in the CALFED PEIS/R, and focuses on the subsequent action of evaluating the enlargement of Shasta Lake.

Although conditions have changed since the CALFED Programmatic ROD was issued in July 2000, the San Francisco Bay/Sacramento San Joaquin Delta (Bay-Delta) problems for which the alternatives were formulated persist today. The purpose of CALFED was to develop and implement a long-term comprehensive plan that would restore ecological health and improve water management for beneficial uses of the Bay-Delta system. The goal of CALFED was to concurrently and comprehensively address problems of the Bay-Delta system within four critical resource categories: ecosystem quality, water quality, water supply reliability, and levee system integrity. Although conditions have changed in the system since 2000 and progress has been made towards the CALFED goals, the fundamental needs for which the CALFED alternatives were formulated to address are still relevant today. For example, unreliable water supply, declining fish and wildlife habitat, continuing water quality issues, and the levee system are still key concerns for the Bay-Delta system. Accordingly, there is no new information or substantially changed circumstances that require Reclamation to revisit the CALFED alternatives as the alternatives, analyses, and recommended actions remain relevant today.

The CALFED PEIS/R was a programmatic-level document to select a long-term plan – Preferred Program Alternative – for implementation over a 30-year time frame. As described in the CALFED Programmatic ROD:

> *The Preferred Program Alternative is a set of programmatic actions, studies, and conditional decisions. It includes the broadly described actions that set the long-term overall direction of the Program. The description of the alternative is programmatic in nature, intended to help agencies and the public make decisions on the broad methods to meet program purposes. The Preferred Program Alternative description is an important legal element of compliance with CEQA and NEPA. The Preferred Program Alternative is not intended to define the site specific actions that will ultimately be implemented.*

This EIS builds on the CALFED PEIS/R analysis to account for updates to hydrology, demands, facilities, and CVP and SWP water operations; recent and relevant Biological Opinions (BO); and reasonably foreseeable actions expected to occur in the study area to provide more specific information about the potential for the action alternatives to cause wide-ranging effects.

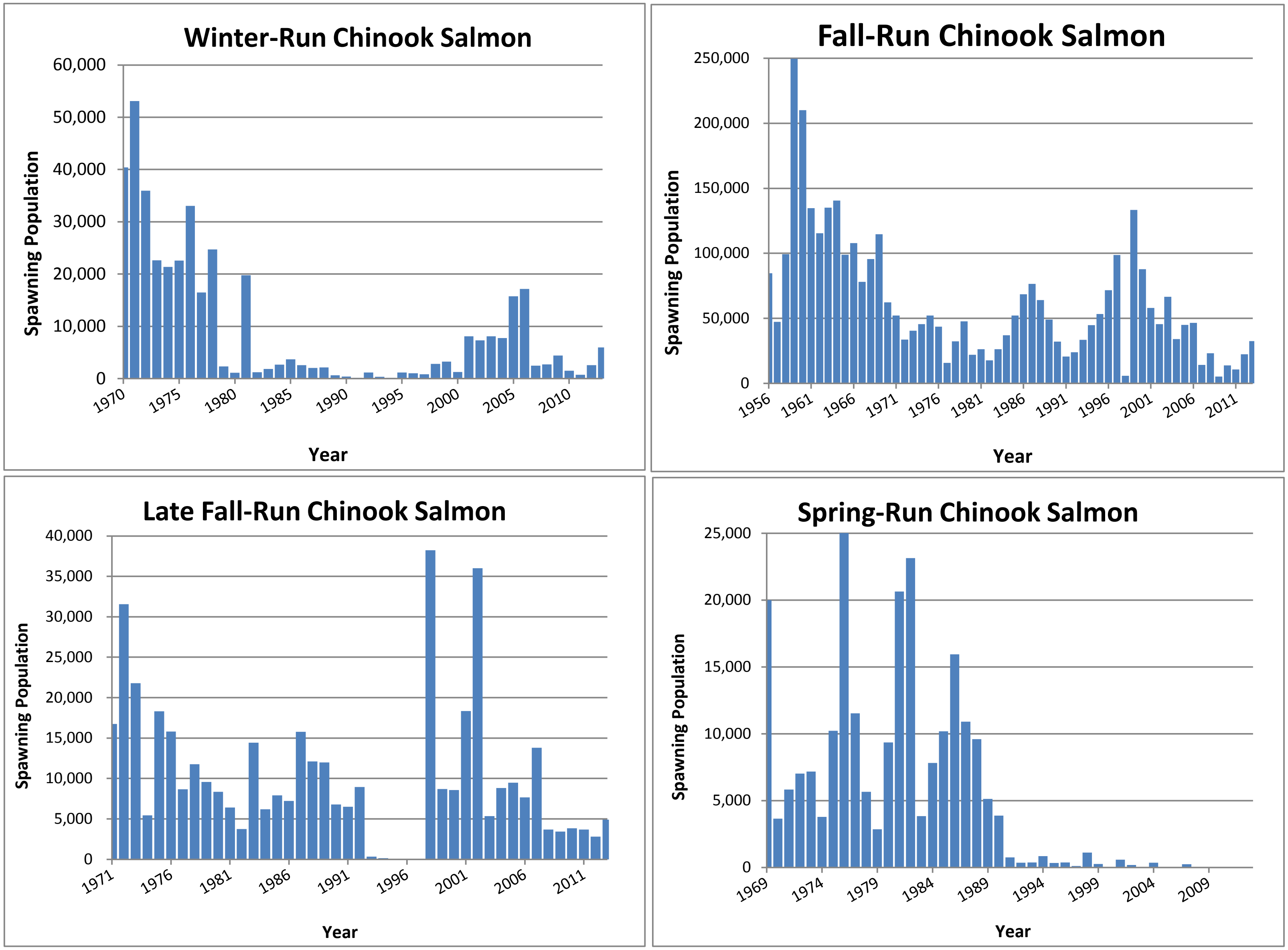
Water and Related Resources Problems, Needs, and Opportunities

Based on the overall feasibility study authority, and concerns expressed about existing and likely future water and related resources issues, following is a description of identified major water resources problems, needs, and opportunities in the primary SLWRI study area.

Anadromous Fish Survival

The Sacramento River system supports four separate runs of Chinook salmon: fall-, late fall-, winter-, and spring-run. The adult populations of the four runs of salmon and other important fish species that spawn in the upper Sacramento River have declined considerably over the last 40 years (Figure 1-2) (CDFW 2014). Several fish species in the upper Sacramento River have been listed as endangered or threatened, as defined by the Federal Endangered Species Act (ESA): Sacramento River winter-run Chinook salmon (endangered), Central Valley spring-run Chinook salmon (threatened), Central Valley steelhead (threatened), and the Southern Distinct Population Segment of North American green sturgeon (threatened). Two of these species also are listed as endangered or threatened, as defined by the California Endangered Species Act (CESA): Sacramento River winter-run Chinook salmon (endangered) and Central Valley spring-run Chinook salmon (threatened).

Numerous factors have contributed to these declines, including unstable water temperature, loss of historic spawning areas and suitable rearing habitat, water diversions from the Sacramento River, drought conditions, reduction in suitable spawning gravels, fluctuations in river flows, toxic acid mine drainage, high rates of predation, unsustainable fish harvests, and unsuitable ocean conditions. One of the most significant environmental factors affecting Chinook salmon is unsuitable water temperature in the Sacramento River (NMFS 2014). Water temperatures that are too high or, less commonly, too low, can be detrimental to the various life stages of Chinook salmon. Elevated water temperatures can negatively impact holding and spawning adults, egg viability and incubation, preemergent fry, and rearing juveniles and smolts, significantly diminishing the next generation of returning spawners. Stress caused by high water temperatures also may reduce the resistance of fish to parasites, disease, and pollutants.



Source: CDFW, 2014

Figure 1-2. Chinook Salmon Historic Spawning Populations in the Sacramento River

Releases of cold water stored behind Shasta Dam can significantly improve seasonal water temperatures in the Sacramento River for anadromous fish during critical periods. The National Marine Fisheries Service (NMFS) *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead* states that prolonged droughts depleting the cold-water stored in Shasta Reservoir, or some related failure to manage cold-water storage, could put populations of anadromous fish at risk of severe population decline or extinction in the long-term (NMFS 2014). The risk associated with a prolonged drought is especially high in the Sacramento River, as Shasta Reservoir is intended to maintain only one year of carryover storage. The recovery plan emphasizes that, under current conditions, even two consecutive years of drought could reduce Shasta Reservoir storage to levels insufficient to support the Sacramento River winter-run Chinook salmon spawning and incubation season.

Conversely, water that is too cold is detrimental to the rapid growth of rearing juveniles. Following construction of Shasta Dam, water released in the spring was unusually cold and prevented the characteristic rapid growth of fall-run and late fall-run juvenile Chinook salmon. Reduced growth rates result in increased risk for predation and entrainment at unscreened and inadequately screened diversions.

Various Federal, State, and local projects are addressing each of the aforementioned factors contributing to anadromous fish population declines. Recovery actions range from changing the timing and magnitude of reservoir releases to changing the temperature of released water. In May 1990, State Water Resources Control Board (State Water Board) issued Water Rights Order 90-5, which included temperature objectives for the Sacramento River to protect winter-run Chinook salmon. This order was reinforced by the 1993, 2004, and 2009 NMFS BO for winter-run Chinook salmon, which established certain operating parameters for Shasta Reservoir. The State Water Board action and the NMFS BOs set minimum flows in the river downstream from Keswick Dam and minimum Shasta Reservoir carryover storage targets primarily to affect water temperatures during key periods.

In addition to flow requirements, structural changes were made at Shasta Dam to change the temperature of released water, such as construction of a temperature control device (TCD), completed in 1997. The TCD can be used to selectively draw water from different depths within the lake, including the deepest, to help maintain river water temperatures beneficial to salmon. The TCD is effective in helping to reduce winter-run Chinook salmon mortality in some critical years,[1] and for fall- and spring-run Chinook salmon in below-normal water years.

[1] Throughout this document, water year types are defined according to the Sacramento Valley Index Water Year Hydrologic Classification unless specified otherwise.

However, implementing requirements in the Trinity River ROD (Reclamation 2000), as amended, may reduce water temperature improvements provided by the TCD at Shasta Dam. One of the major elements of the Trinity River ROD is reducing the average annual export of Trinity River water from 74 percent to 52 percent of the flow (Reclamation 2000). This reduces flow from the Trinity River basin into Keswick Reservoir, and then into the Sacramento River. Because water diverted from the Trinity River is generally cooler than flows released from Shasta Dam, implementing the Trinity River ROD offsets some of the benefits derived from the TCD.

With the exception of spring-run Chinook salmon, the average Chinook salmon spawning population in the Sacramento River since 1999 has increased compared with the previous 20 years (1979 to 1998) (CDFW 2014a). This increase in salmon populations is likely due primarily to minimum release requirements at Shasta Dam and the TCD. Additionally, changes in operating the Red Bluff Diversion Dam and the Red Bluff Pumping Plant (RBPP) have benefited Chinook salmon populations in the Sacramento River. However, there is a continual need for cool water in the Sacramento River, especially in dry and critical years, to promote anadromous fish survival and reduce the risk of extinction. In the future, effects of climate change on operations at Shasta Lake could potentially result in changes to water temperature, flow, and ultimately, fish survival. As described in the Climate Change Modeling Appendix, climate change could result in increased inflows to Shasta Lake and higher reservoir releases because of an increase in winter and early spring inflow into the lake from high intensity storm events. The change in reservoir releases could be necessary to manage flood events resulting from these potentially larger storms. Climate change could also result in reduced end-of-September carryover storage volumes, resulting in lower lake levels for a portion of the year, and a smaller cold-water pool, resulting in warmer water temperature and reduced water quality within Shasta Reservoir. Most importantly, it is expected that climate change may result in increased water temperatures downstream from Shasta Dam, particularly in summer months, and more frequent wet and drought (particularly extended drought) years. Increased water temperatures and extended drought periods may compound the threats to anadromous fish in the Sacramento River.

Water Supply Reliability

California's water supply system faces critical challenges with demands exceeding supplies for urban, agricultural, and environmental water uses across the State. The *California Water Plan Update 2013* (DWR 2014) concludes that California is facing one of the most significant water crises in its history; drought impacts are growing, and climate change is affecting statewide hydrology. Despite significant physical improvements in water resource systems and in system management over the past few decades, California still faces unreliable water supplies, continued depletion and degradation of groundwater resources, habitat and species declines, and unacceptable risks from flooding (DWR 2014). Compounding these issues, Reclamation's *Water*

Supply and Yield Study (Reclamation 2008) describes dramatic increases in population, land use changes, regulatory requirements, and limitations on storage and conveyance facilities, further straining available water supplies and infrastructure to meet water demands. Resulting unmet water demands have led to increases in competition for water supplies among urban, agricultural, and environmental uses.

The following subsections discuss identified key issues related to water supply reliability in California, including current and estimated water shortages, anticipated effects of population growth and climate change on water supply and demand, and limitations on system flexibility. The final subsection discusses strategies for meeting future statewide water supply needs.

Estimated Water Supply Shortages

Projecting accurate and quantified water supply and shortages in California is complex; numerous variables exist and, just as important, numerous opinions have been expressed regarding these variables. Table 1-1 displays estimated water demands, available supplies, and shortages for the Central Valley and the State under existing conditions (Reclamation 2008). Current water supply shortages for the State are estimated at 2.3 and 4.1 million acre-feet (MAF) for average and dry years, respectively. As shown in Table 1-2, without further investment in water management and infrastructure, future shortages are expected to increase to approximately 4.9 and 6.1 MAF in average and dry years, respectively, by 2030. Representative demands for dry and average years were based on water use data from the *California Water Plan Update 2005* (DWR 2005), adjusted for population growth, increasing urban water use, and reductions in irrigated acreage and environmental flow due to insufficient water supplies. Shortages were determined on a regional basis, assuming that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another.

Table 1-1. Estimated Water Demands, Supplies, and Shortages Under Existing Conditions[1]

Item	Hydrologic Basin						State of California	
	Sacramento		San Joaquin		Two-Basin Total			
	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]
Population (million)[3]	2.9		2.0		4.9		36.9	
Water Demand (MAF)								
Urban	0.9	0.9	0.6	0.6	1.5	1.5	8.9	9.0
Agricultural	8.7	8.7	7.0	7.0	15.7	15.7	34.2	34.2
Environmental	11.9	9.4	3.1	2.3	15.0	11.7	17.5	13.9
Total	***21.5***	***19.0***	***10.7***	***9.9***	***32.2***	***28.9***	***60.6***	***57.1***
Water Supply (MAF)								
Urban	0.9	0.9	0.6	0.6	1.5	1.5	8.8	8.4
Agricultural	8.7	8.6	6.9	7.0	15.6	15.6	33.2	32.0
Environmental	11.5	8.7	2.5	1.8	14.0	10.5	16.3	12.6
Total	***21.1***	***18.2***	***10.0***	***9.4***	***31.1***	***27.6***	***58.3***	***53.0***
Total Shortage (MAF)[4]	**0.4**	**0.8**	**0.7**	**0.5**	**1.1**	**1.3**	**2.3**	**4.1**

Notes:

[1] Water demands, supplies, and shortages are from the 2008 Reclamation Water Supply and Yield Study

[2] Representative dry and average year supplies and demands were based on adjusted water use and supply data from the California Water Plan Update 2005 (DWR 2005).

[3] Year 2005 Population estimates are from the California Department of Finance (2010)

[4] Total shortages are calculated as the sum of shortages for each category by region (e.g., North Coast, Sacramento River) and, therefore, may not equal the difference between total demands and supplies. Shortages were determined on a regional basis, assuming that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another. Detailed estimates of shortages for each region can be found in the 2008 Reclamation Water Supply and Yield Study in Table A-1 (dry year) and Table A-2 (average year). For categories where supply is greater than demand, the shortage is equal to zero.

Key:
MAF = million acre-feet

Table 1-2. Estimated Water Demands, Supplies, and Shortages for 2030[1]

Item	Sacramento and San Joaquin Hydrologic Basins		State of California	
	Two-Basin Total			
	Average Year[2]	Dry Year[2]	Average Year[2]	Dry Year[2]
Population (million)[3]	10.5		49.2	
Water Demand (MAF)				
Urban	2.4	2.5	11.9	12.0
Agricultural	15.0	15.0	31.4	31.4
Environmental	14.9	11.7	17.5	14.0
Total	***32.3***	***29.2***	***60.8***	***57.4***
Water Supply (MAF)				
Urban	1.5	1.5	8.4	8.0
Agricultural	15.6	15.6	32.8	31.5
Environmental	14.0	10.5	16.3	12.6
Total	***31.1***	***27.6***	***57.5***	***52.1***
Total Shortage (MAF)[4]	**1.8**	**2.2**	**4.9**	**6.1**

Notes:
[1] Water demands, supplies, and shortages are from the 2008 Reclamation Water Supply and Yield Study
[2] Representative dry and average year supplies and demands were based on water use and supply data from the California Water Plan Update 2005 (DWR 2005) adjusted for population growth, increasing urban water use, and reductions in irrigated acreage and environmental flow due to insufficient water supplies.
[3] Year 2030 Population estimates are from the California Department of Finance (2010)
[4] Total shortages are calculated as the sum of shortages for each category by region (e.g., North Coast, Sacramento River) and, therefore, may not equal the difference between demands and supplies. Shortages were determined on a regional basis, assuming that limitations on conveyance and storage would prevent surpluses from one region or use category from filling shortages in another. Detailed estimates of shortages for each region can be found in the 2008 Reclamation Water Supply and Yield Study in Table A-4 (dry year) and Table A-5 (average year). For categories where supply is greater than demand, the shortage is equal to zero.

Key:
MAF = million acre-feet

Potential Effects of Population Growth on Water Demands

A major factor in California's future water picture is population growth. California's population is expected to increase by just over 60 percent by 2050(California Department of Finance 2010) and could force some of the existing water supplies currently identified for agricultural uses to be redirected to urban uses. A portion of the increased population in the Central Valley would occur on lands currently used for irrigated agriculture. Water that would have been needed for these lands for irrigation would instead be used to serve replaced urban demands. However, this would only partially offset the required agricultural-to-urban water conversion needed to sustain projected urban water demands, since much of the growth would occur on nonirrigated agricultural lands.

The *California Water Plan Update 2013* (DWR 2014) estimates changes in future water demands by 2050 considering three different population growth scenarios as well as climate change. Table 1-3 shows results of this study for an average water year (DWR 2014). The first scenario (Current Trends) assumes that recent population growth trends will continue until 2050. The second scenario (Lower than Current Trends) assumes that population growth will be slower than currently projected. The third scenario (Higher than Current Trends) assumes that population growth will be faster than currently projected, with nearly 70 million people living in California in 2050. Estimated reductions in agricultural water demands in Table 1-3 represent decreases in future agricultural water demands due to conversion from agricultural to urban land uses. Under the Higher than Current Trends scenario, as much as 1.8 MAF of increased demand is projected. This would be in addition to the current water shortages estimated in Table 1-1.

Table 1-3. Estimated Annual Change in Water Demand in California for 2050 Considering Different Population Growth Scenarios

Item	Current Trends	Lower than Current Trends	Higher than Current Trends
Population (million)	51.0	43.9	69.4
Irrigated Crop Acreage (million)	8.9	9	8.6
Water Demand Change[1] (MAF)			
Urban	2.9	1.3	6.1
Agricultural	-3.5	-3.0	-4.3
Total	***3.5***	***-1.5***	***8***

Source: DWR 2014

Note:

[1] Estimated water demand change is the difference between the average demands for 2043—2050 and 1998—2005.

Key:

MAF = million acre-feet

Potential Effects of Climate Change

Another potentially significant factor affecting water supply reliability is climate change. Potential effects of climate change are many and complex (DWR 2006), varying through time and geographic location across the State (Reclamation 2011). Changes in geographic distribution, timing, and intensity of precipitation are projected for the Central Valley (Reclamation 2011), which could broadly impact rainfall runoff relationships important for flood management as well as water supply. Additionally, there is potential for climate change to increase annual water demand compared to a repeat of historical climate (DWR 2014). Other possible impacts range from potential sea level rise, which could impact coastal areas and water quality, to impacts to overall system storage for water supply.

A reduction in total system storage is widely predicted to occur with climate change. Precipitation held in snowpacks makes up a significant quantity of total annual supplies needed for urban, agricultural, and many environmental uses. It is expected that in the future, climate change may significantly reduce water held in snowpacks in the Sierra Nevada (Reclamation 2011, DWR 2014).

Further potential for reductions in water conservation space in existing reservoirs in the Central Valley is anticipated because of increasing needs for additional space for flood management purposes. These potential reductions could significantly impact available water supplies, especially for reservoirs immediately upstream from large urban areas such as Folsom Lake on the American River, upstream from the greater Sacramento metropolitan area. During drought periods, supplies could be further reduced, and expected shortages would be substantially greater.

System Flexibility

In addition to concerns about future water supply and demand, California's Federal and State water systems lack flexibility in timing, location, and capacity to meet the multiple objectives of the projects. Central Valley Project (CVP) and State Water Project (SWP) flexibility has diminished with population growth and increased environmental and ecosystem commitments and requirements (Reclamation 2008). Complicating this issue is the variability associated with water resources in California. Precipitation in California is seasonably, temporally, and spatially variable, and urban, agricultural, and environmental water users have variable needs for quantity, quality, timing, and place of use.

California's water systems face the threat of too much water during floods, and too little water to meet demands during dry and critical water years. Chronic water shortages have led to increases in groundwater usage, which has led to groundwater overdraft in many regions across the State. Groundwater overdraft can cause permanent declines in groundwater levels, long-term reductions in groundwater supplies, land subsidence, decreases in water quality, a greater potential for salt water intrusion, and lasting environmental impacts. Challenges are greatest during dry years, when water supplies are less available (DWR 2014).

Increasing CVP/SWP operational constraints have led to growing competition for limited system resources between various users and uses. Urban and required environmental water uses have each increased, resulting in increased competition and conflicting demands for limited water supplies. For example, the Central Valley Project Improvement Act (CVPIA), implemented in 1993, dedicated 800,000 acre-feet of CVP water supplies to the environment as well as additional water supplies for the Trinity River and wildlife refuges. Current BOs by NMFS and U.S. Department of Interior, Fish and Wildlife Service (USFWS), resulting in increased Delta pumping constraints and other operational restrictions, coupled with drought conditions, have even further decreased CVP deliveries. As competition for limited resources between various uses grows, water management flexibility and adaptability will be even more necessary in the future.

Potential Approaches to Address Water Supply Needs

As noted by Reclamation's *Water Supply and Yield Study* (Reclamation 2008), the *California Water Plan Update 2013* (DWR 2014), and the CALFED Programmatic ROD (2000), an integrated portfolio of solutions, regional and statewide, is needed to meet future water supply needs. The *Water Supply and Yield Study* stated that a "variety of storage and conveyance projects and water management actions have the potential to help fill [the] gap" between water supply and demand in California. The *California Water Plan Update 2013* concluded that to improve public safety, foster environmental stewardship, and support economic stability, California must continue its commitment to integrated water management, promote better alignment of government agency efforts at all levels, and encourage greater investment in innovation and infrastructure, including increased surface storage. Accordingly, California must invest in reliable, high quality, and affordable water conservation; efficient water management; and development of water supplies. Major efforts by multiple agencies are needed to address the complex water resources issues in the State, as demands are expected to continue to exceed supplies in the future.

To avoid major impacts to the economy, overall environment, and standard of living in California, actions to conserve existing supplies and optimize the use of existing facilities will be needed. Additionally, development of additional water sources and increased storage and delivery capability are critical for providing reliable water supplies for expanding municipal and industrial (M&I) uses and to maintain adequate supplies for agricultural and environmental purposes.

Ecosystem Resources

The health of the Sacramento River ecosystem, as elsewhere in the Central Valley, has been impacted in the last century by conflicts over the use of limited natural resources, particularly water resources. Many of California's rivers and streams have been harnessed for beneficial uses such as hydropower, flood damage reduction, and water supply, contributing to a decline in habitat and native species populations, and a resulting increase in endangered or threatened species listings under the ESA and CESA.

Construction of Shasta Dam has had both negative and positive effects on environmental resources in the region. While construction of the dam displaced valuable riverine and upland habitat, it also created shoreline and shallow water habitat for aquatic, terrestrial, and avian species in the reservoir area. For example, Shasta Lake is home to a substantial concentration of nesting bald eagles in California.

Shasta Lake Area

Various activities have impacted natural resources upstream from Shasta Dam, within the lake, on adjacent lands, and in and near tributary streams. Historical mining, ore processing practices and resulting acid mine drainage, and fire suppression are among the activities causing the greatest challenges to ecosystem resources in this area. Although mines in this area are no longer operational and are currently undergoing remediation, they continue to remain a documented source of metals, acidity, and sediments in the reservoir area. In addition, fire suppression activities have resulted in an accumulation of vegetation cover in the watershed and a decrease in the return intervals of natural fires, both of which potentially affect erosion processes and sediment delivery to tributaries and increase the likelihood of higher intensity fires (USFS 2010). To guide management of the Shasta-Trinity National Forest (STNF), the U.S. Department of Agriculture, Forest Service (USFS) has prepared the *Shasta-Trinity National Forest Land and Resource Management Plan* (USFS 1995). Primary goals of the *Shasta-Trinity National Forest Land and Resource Management Plan*, which was implemented in 1995, are to integrate a mix of management activities that allows use and protection of forest resources; meets the needs of guiding legislation; and addresses local, regional, and national issues. The *Shasta-Trinity National Forest Land and Resource Management Plan* is intended to guide implementation of the *Aquatic Conservation Strategy of the Northwest Forest Plan* (USFS 1994) for protection and management of riparian and aquatic habitats adjacent to Shasta Lake.

Opportunities exist to further support ongoing USFS programs. These opportunities include improving and restoring environmental conditions by developing self-sustaining natural habitat in the area of Shasta Lake and its tributaries to benefit fish and wildlife resources.

Downstream from Shasta Dam

Land and water resources development has caused major resource problems and challenges in the Sacramento River basin, including decreases in anadromous fish and wildlife populations and losses of riparian, wetland, floodplain, and shaded riverine habitat. These decreases and losses have resulted in reduced populations of many plant and animal species.

The quantity, quality, diversity, and connectivity of riparian, wetland, floodplain, and shaded riverine habitat along the Sacramento River have been severely limited through confinement of the river system by levees, reclamation of adjacent lands for farming, bank protection, channel stabilization, and land development. Modification of seasonal flow patterns by dams and water diversions also has inhibited the natural channel-forming processes that drive riparian habitat succession. It is estimated that less than 5 percent of the historical riparian vegetation within the Sacramento River basin remains today (USFWS 2014).

Decreases in quality and quantity of habitat have resulted in reduced populations of various fish and wildlife species. The low populations and questionable sustainability of these species have led to an increase in listings under the ESA and CESA in recent years. Introduction of nonnative species has also contributed to the decline in native animal and plant species. In addition, lack of linear continuity of riparian habitat has impacted the movement of wildlife species among habitat areas, adversely affecting dispersal, migration, emigration, and immigration. For many species, this has resulted in reduced wildlife numbers and population viability.

Ecosystem restoration along the Sacramento River has been the focus of several ongoing programs, including the Senate Bill 1086 Program, CVPIA, CALFED, and Central Valley Habitat Joint Venture. These and numerous local programs have been established to address ongoing conflicts over the use of limited resources within the Central Valley. Much effort has been directed in the upper Sacramento River region above the RBPP toward restoring or improving anadromous fisheries, which provide recreational and commercial values in addition to their environmental value. Despite these efforts, a significant need remains to conserve and restore ecosystem resources along the Sacramento River.

Endangered and threatened fish and wildlife populations, critical habitat, and sensitive Delta ecosystems are also declining. The decline is especially pronounced in the case of pelagic fish species in the Delta, including delta smelt, striped bass, threadfin shad, and longfin smelt. Recent monitoring results indicate that the threatened delta smelt population continues to remain at or near all-time lows. In 2006, the USFWS was petitioned to upgrade the status of delta smelt to endangered (The Center for Biological Diversity et al. 2006). In 2010, the USFWS conducted their 5-year review and found delta smelt warranted the upgrade in status, however, the listing was precluded by other higher priority-listing actions (Volume 75, Federal Register (FR), page 17667 (75 FR 17667 (April 7, 2010))). Longfin smelt were petitioned for listing as endangered in 2007 (The Center for Biological Diversity et al. 2007). The USFWS found that the Bay-Delta DPS does warrant listing, however, as with the delta smelt, the listing is precluded by other higher priority actions. Therefore, longfin smelt have been added to the candidate list (77 FR 19756 (April 2, 2012)).

In recognition of the challenges facing water management in California, and the need to develop new strategies for a sustainable Delta ecosystem that would continue to support its economic functions, various planning efforts are underway. Current planning efforts, such as the Bay Delta Conservation Plan (BDCP)/ Delta Habitat Conservation and Conveyance Program are focused on developing ecological solutions to protect Delta fisheries while providing a sustainable and reliable water conveyance system for the CVP and SWP.

Flood Management

Large and small communities and agricultural lands in the Central Valley are subject to flooding along the Sacramento River. U.S. Army Corps of Engineers (USACE), in partnership with DWR, has worked to assess basin-wide flood management issues and identify options in the Sacramento River basin to address these issues. Measures to reduce high flows in the Sacramento River include spilling floodwater into bypass areas through historical overflow areas, streams, conveyance canals, and weirs. The comprehensive flood control system in the Sacramento River basin includes river, canal, and stream channels, levees, flood relief bypasses, weirs, flood relief structures, a natural overflow area, outfall gates, and drainage pumping plants. USACE and DWR continue to develop improvements associated with the Sacramento River Bank Protection Project and to assist in local flood damage reduction projects along the Sacramento River. DWR is currently working on the implementation of the Central Valley Flood Protection Plan, which was adopted in 2012 to address flood issues throughout the Sacramento and San Joaquin valleys and the Delta.

Flooding poses risks to human life, health, and safety. Threats to the public from flooding are caused by many factors, including overtopping or sudden failures of levees, which can cause deep and rapid flooding with little warning, threatening lives and public safety. In addition, urban development in flood-prone areas has exposed the public to the risk of flooding.

Physical impacts from flooding occur to residential, agricultural, commercial, industrial, institutional, and public property. Damages occur to buildings, contents, automobiles, and outside property, including agricultural crops, equipment, and landscaping. Physical damages include cleanup costs and costs to repair roads, bridges, sewers, power lines, and other infrastructure components. Nonphysical flood losses include income losses and the cost of emergency services, such as flood fighting and disaster relief.

Even though a project to enlarge Shasta Dam and Reservoir has the potential to significantly reduce flood flows in the upper Sacramento River, influencing factors exist that can conflict with flood operation. Flood management operations at Shasta Dam, even with explicit rules provided in the Shasta Dam and Lake Flood Control Diagram (USACE 1977), are difficult to manage during a flood event. This is primarily due to the extreme inflow volumes to Shasta Reservoir that can occur over long periods, numerous points of inflow along the river downstream from Shasta Dam, and multiple points of operational interest downstream. The primary downstream control point along the Sacramento River that determines reservoir releases under real-time operations is Bend Bridge.

Other unofficial factors enter into flood management decisions, such as peak flows at Hamilton City or other rural communities that are at risk of flooding. These factors, combined with the uncertainty of storm forecasting, could lead to a reduction in flood operation flexibility at Shasta Dam. Should this occur, it could cause a cascading impact on effective flood management downstream to the Delta. Accordingly, there is a need to review flood control operations at Shasta Dam.

Hydropower

While California is the second largest consumer of electricity in the Nation, it is also the most energy efficient Although California has 12 percent of the Nation’s population, it uses only 7 percent of the Nation’s electricity (DOE

2014). This makes California the most energy-efficient State per capita in the Nation. Even so, demands for electricity are growing at a rapid pace.

California's peak demand for electricity is expected to increase at a rate of approximately 1.5 percent per year through 2022, from about 60,000 megawatts (MW) in 2011 to about 70,000 MW by 2022 (California Energy Commission 2012). There are, and will continue to be, increasing demands for new electrical energy supplies, including clean energy sources, such as hydropower. Executive Orders S-14-08 and S-21-09, issued in 2008 and 2009 respectively, established a goal of using renewable energy sources, including hydropower, for 33 percent of the State's energy consumption by 2020 (California Public Utilities Commission 2011). To meet renewable energy goals, significant increases in non-dispatchable intermittent renewable resources, such as wind and solar generation, will need to be added to California's power system. This means that other significant flexible generation resources will be needed to support and integrate renewable generation. Adding to the need for additional energy sources, existing nuclear power plants are nearing the end of their design lives and some may be offline within the next 10 to 20 years. For example, the San Onofre Nuclear Generating Station in San Diego County is in the process of decommissioning.

Recreation

As the population of the State of California continues to grow, demands will increase significantly for water-oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. According to the California Water Plan Update 2014 (DWR 2014), the Central Valley is experiencing dramatic population growth, but currently has insufficient access to recreation opportunities. Further increases in demand, accompanied by relatively static recreation resources, will cause additional issues at existing recreation areas. These challenges will be especially pronounced at Shasta Lake, which is one of the most visited recreation destinations in the state and in the region. Even under current levels of demand, USFS, which manages recreation at Shasta Lake, has expressed concern about seasonal capacity problems at existing marinas and USFS facilities. A significant and increasing need exists to improve recreation-related facilities and conditions at Shasta Lake.

Water Quality

The Sacramento River and the Delta support fish and wildlife while providing water supplies for urban, agricultural, and environmental uses across the State. The Sacramento River downstream from Keswick Dam is critical habitat for the migration and reproduction of Chinook salmon (NMFS 2014) and the Delta is one of the largest ecosystems for fish and wildlife habitat and production in the United States (Regional Water Boards, State Water Board, and CalEPA 2006). However, saltwater intrusion, municipal discharges, agricultural drainage, and water project flows and diversions have led to water quality issues within the Delta, particularly related to salinity, that have resulted in significant declines in pelagic populations (Cal Water Boards, State Water Board, and CalEPA 2006). In the Sacramento River and its tributaries, water temperatures, which are vital for anadromous fish survival, are affected by variations in climate and rainfall as well as operating conditions of various Federal, State, and local water supply systems. Additionally, urban and agricultural runoff, and runoff and seepage from abandoned mining operations, have resulted in elevated levels of pesticides, phosphorous, mercury, and other metals in the Sacramento River.

Several environmental flow goals and objectives in the Central Valley, including the Delta, have been established through legal mandates to address the impacts of water operations and water quality deterioration on the Sacramento River basin and Delta ecosystems and on endangered and threatened fish populations. Planning efforts, such as the BDCP, are intended to allow implementation of projects that restore and protect water supply and reliability, water quality, and ecosystem health in the Delta to proceed within a stable regulatory framework. Additional operational flexibility is needed to provide further opportunities to improve Sacramento River and Delta water quality conditions. Increasing storage in Shasta Reservoir could provide increased CVP operational flexibility to meet water quality goals in the Delta, as well as provide more cold-water storage in critical years to improve Sacramento River water temperatures.

Existing and Future Resources Conditions in Study Area

Shasta Dam and Reservoir are located on the upper Sacramento River in Northern California about 9 miles northwest of the City of Redding, within Shasta County. The SLWRI includes both a primary and extended study area because of the potential influence of the proposed modification of Shasta Dam and Reservoir, and subsequent water deliveries on resources over a rather large geographic area. The primary study area for the SLWRI encompasses Shasta Dam and Lake; lower reaches of three primary tributaries flowing into Shasta Lake (Sacramento River, McCloud River, and Pit River) and all smaller tributaries flowing into the lake; Trinity Lake and Lewiston Reservoir; and the Sacramento River downstream to about the RBPP, including tributaries at their confluence. Figure 1-3 shows the geographic extent of the primary study area.

The extended study area includes other areas of California with resource programs or projects that could potentially be indirectly influenced by modifying Shasta Dam and Reservoir. The extended study area encompasses the Sacramento River downstream from the RBPP, the Delta, portions of major tributaries, namely the lower Feather and American Rivers, parts of the lower San Joaquin River, and facilities and water service areas of the CVP and SWP. Detailed descriptions of the study area and existing conditions for physical, biological, cultural, and socioeconomic resources within the SLWRI study area is included in the accompanying EIS and the Physical Resources Appendix, Biological Resources Appendix, Cultural Resources Appendix, and

Socioeconomics Appendix. Following is a brief description of the likely future resources conditions in the study area.

Likely Future Conditions

Identification of the magnitude of potential water resources and related problems, needs, and opportunities in the study area is based not only on the existing conditions, but also on an estimate of how these conditions may change in the future. Predicting future changes to the physical, biological, cultural, and socioeconomic environments in the primary and extended study areas is complicated by ongoing programs and projects and potential changes in regulatory requirements. Several ecosystem restoration, water quality, water supply, and levee improvement projects are likely to be implemented in the future. Collectively, these efforts may improve ecosystem resources, Delta water quality, water supply, and levees. Much of this improvement would be based on separate opportunities that are not integrated in a single plan or part of an approved and funded program.

The following sections summarize likely future conditions for physical, biological, cultural, and socioeconomic resources within the SLWRI study area, as described in the accompanying EIS.

Physical Resources Environment

Basic physical conditions in the primary and extended study areas are expected to remain relatively unchanged in the future. Continued development in urban and suburban areas is expected. Ongoing restoration efforts along rivers are expected to marginally improve natural riverine processes. Without major physical changes to the river systems, hydrologic conditions may remain unchanged. However, the region’s hydrology could be altered should there be significant changes in global climatic conditions; scientific work in this field of study is continuing. Without major changes in hydrology, topography, or geology, sedimentation and erosion are also likely to remain unchanged.

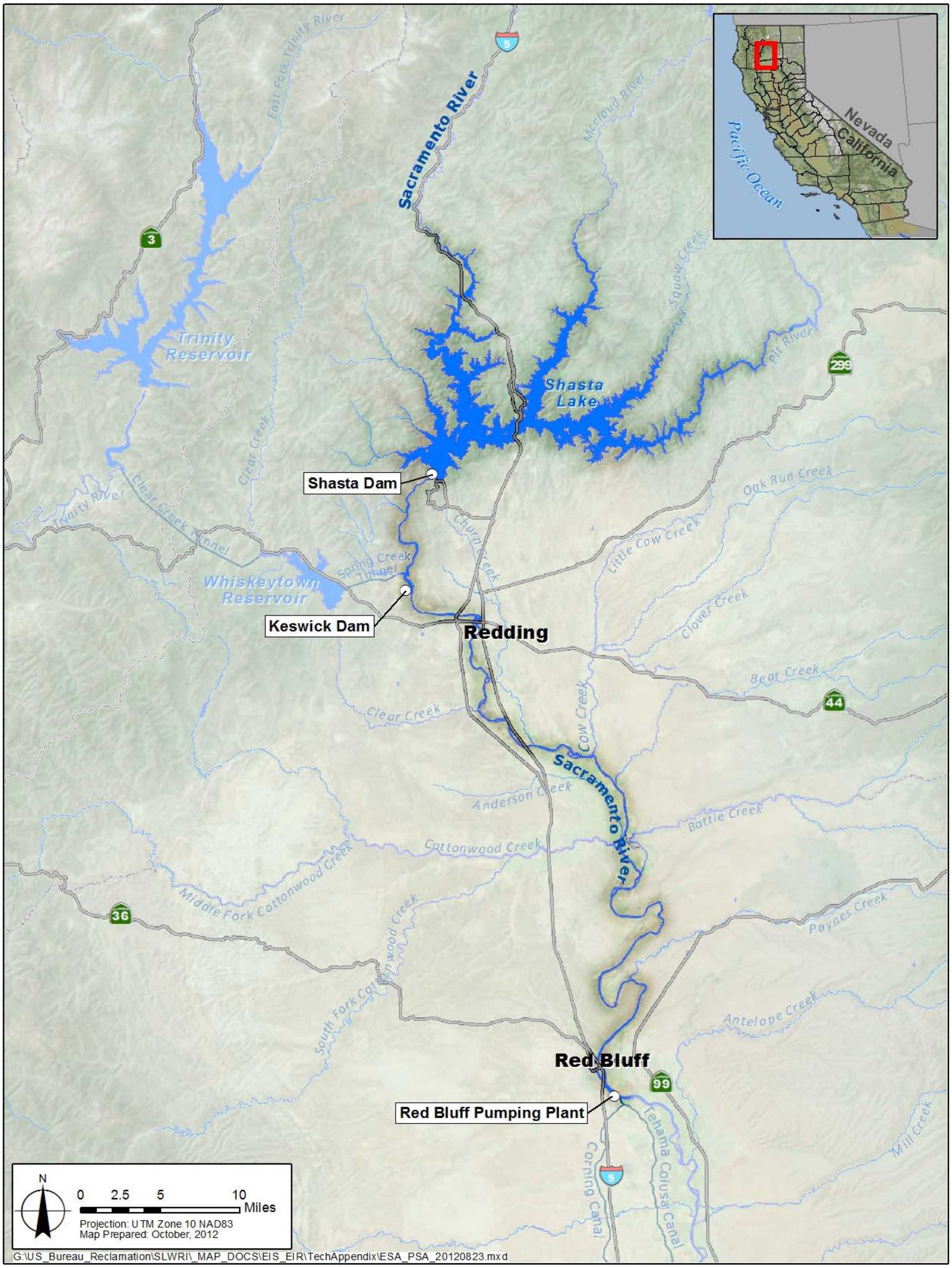


Figure 1-3. Shasta Lake Water Resources Investigation Primary Study Area – Shasta Lake Area and Sacramento River from Shasta Dam to Red Bluff Pumping Plant

Much effort has been expended to control the levels and types of herbicides, fungicides, and pesticides that can be used in the environment. Further, efforts are underway to better manage the quality of runoff from urban environments to the major stream systems. However, water quality conditions are expected to remain unchanged and similar to existing conditions.

It is unclear to what extent potential changes to the region's climate could occur in association with global climate change. As the population continues to grow and agricultural lands are converted to urban and industrial uses, a general degradation of air quality conditions could occur. However, because of technological innovation and stringent regulations, air quality could improve over time. While similar types and sources of hazardous materials and waste are likely to be present in the future, increasing population will likely increase the potential for hazardous waste issues. Similarly, increasing population will likely affect increases in environmental noise and vibration.

Biological Resources Environment

Efforts are underway by numerous agencies and groups to restore various biological conditions throughout the primary and extended study areas. Accordingly, major areas of wildlife habitat, including wetlands and riparian vegetation areas, are expected to be protected and restored. However, as population and urban growth continues, and land uses are converted to urban centers, many wildlife and plant species especially dependent on woodland, oak woodland, and grassland habitats may be adversely affected.

Through the significant efforts of Federal and State wildlife agencies, populations of special-status species in the riverine and nearby areas are estimated to generally remain as under existing conditions. Although increases in anadromous and resident fish populations in the Sacramento River could continue through implementation of CVPIA programs and other projects such as the Battle Creek Salmon and Steelhead Restoration Project, some degradation will likely occur through actions that reduce Sacramento River flows or elevate water temperatures such as implementation of the Trinity River ROD. Accordingly, populations of anadromous fish are expected to remain generally similar to existing conditions.

No rivers or streams in the primary study area are expected to be added to the list of Federal and/or State wild and scenic resources. The wild and scenic status of the McCloud River is expected to remain as under existing conditions.

Cultural Resources Environment

In the vicinity of Shasta Lake, any archaeological, historic, or ethnographic resources currently affected by erosion due to reservoir fluctuations would continue to be impacted. Artifacts located around the perimeter of the existing reservoir will continue to be subject to collection by recreationalists. Similarly, conditions related to the cultural environment downstream from Shasta Dam are unlikely to change significantly.

Socioeconomic Resources Environment

The State's population is estimated to increase from approximately 37 million in 2005 to about 44 million by 2020, and to approximately 60 million by 2050. Between now and 2050, Shasta and Tehama counties are expected to continue their historic growth trends. According to the California Department of Finance (2007, 2010), Shasta County's population is expected to increase by approximately 86 percent by 2050 to a total of approximately 332,000 residents (2005 population was 179,000). This represents an expected increase in population that is almost 20 percent greater than for the State as a whole. The population of Tehama County is expected to more than double by 2050, with population increasing from approximately 60,000 (in 2005) to 124,000 (California Department of Finance 2007, 2010).

To support these expected increases in population, some conversion of agricultural and other rural land to urban uses is anticipated. More transportation routes are likely to be constructed to connect the anticipated population increase in the Central Valley to transportation infrastructure. Anticipated increases in population growth will also impact visual resources as areas of open space on the valley floor are converted to urban uses.

Increases in population will increase demands for electric, natural gas, and wastewater utilities; public services such as fire, police protection, and emergency services; and water-related and communication infrastructure. The increase in population and aging "baby boomer" generation will increase the need for health services. The region's superior outdoor recreational opportunities and moderate housing cost opportunities are expected to attract increasing numbers of retirees from outside the region and State. An increasing population will produce employment gains, particularly in retail sales, personal services, finance, insurance, and real estate. Recreation is expected to remain an important element of the community and economy in the region.

Anticipated increases in population growth in the Central Valley will also significantly increase demands on water resources systems for additional and reliable Central Valley water supplies, energy supplies, water-related facilities, recreational facilities, and flood management facilities.

Planning Objectives

This section discusses the national planning objectives and objectives, constraints, and other considerations specific to the SLWRI.

National Planning Objectives

The Federal objective is defined in the P&G (WRC 1983) as follows:

> *The Federal objective of water and related resources project planning is to contribute to national economic development consistent with protecting the Nation's environment, pursuant*

to national environmental statutes, applicable executive orders, and other Federal planning requirements.

Contributions to national economic development (NED) are further defined as "increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are direct net benefits that accrue in the planning area and the rest of the Nation" (WRC 1983).

The National Water Resources Policy specified in the Water Resources Development Act of 2007 (Public Law 110-114, Section 2031), is that Federal water resources investments should reflect national priorities, encourage economic development, and protect the environment by doing the following:

- Seek to maximize sustainable economic development
- Seek to avoid the unwise use of floodplains and flood-prone areas and minimize adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used
- Protect and restore the functions of natural systems and mitigate any unavoidable damage to natural systems

In consideration of the many complex water management challenges and competing demands for limited Federal resources, Federal agencies investing in water resources should strive to maximize public benefits, particularly compared to costs. Public benefits encompass environmental, economic, and social goals, including monetary and nonmonetary benefits, and allow for the inclusion of quantified and unquantified benefits. Stakeholders and decision makers expect the formulation and evaluation of a diverse range of alternative solutions. Such solutions may produce varying degrees of benefits and/or impacts relative to the three goals specified above. As a result, trade-offs among potential solutions will need to be assessed and properly communicated during the decision making process.

SLWRI-Specific Planning Objectives

On the basis of the problems, needs, and opportunities identified and defined previously, study authorities and other pertinent direction, including information contained in the CALFED PEIS/R and Programmatic ROD, primary and secondary planning objectives were developed. Primary planning objectives are those which specific alternatives are formulated to address. The primary objectives are considered to have equal priority, with each pursued to the maximum practicable extent without adversely affecting the other. Secondary planning objectives are considered to the extent possible through pursuit of the primary planning objectives.

- **Primary Planning Objective**s:
  - Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream from RBPP.
  - Increase water supply and water supply reliability for agricultural, M&I, and environmental purposes to help meet current and future water demands, with a focus on enlarging Shasta Dam and Reservoir.
- **Secondary Planning Objectives**:
  - Conserve, restore, and enhance ecosystem resources in the Shasta Lake area and along the upper Sacramento River.
  - Reduce flood damage along the Sacramento River.
  - Develop additional hydropower generation capabilities at Shasta Dam.
  - Maintain and increase recreation opportunities at Shasta Lake.
  - Maintain or improve water quality conditions in the Sacramento River downstream from Shasta Dam and in the Delta.

Planning Constraints and Other Considerations

The P&G provide fundamental guidance for the formulation of Federal water resources projects. In addition, basic constraints and other considerations specific to this investigation must be developed and identified. Following is a summary of the constraints and considerations being used for the SLWRI.

Planning Constraints

Fundamental to the plan formulation process is identifying and developing basic constraints specific to this investigation. Planning constraints help guide the plan formulation process. Some planning constraints can also assist in defining existing and likely future resource conditions. Some planning constraints are more rigid than others. Examples of more rigid constraints include congressional direction in study authorizations; other current applicable laws, regulations, and policies; and physical conditions (e.g., topography, hydrology). Other planning constraints are less restrictive but are still influential in guiding the process. Several key constraints identified for the SLWRI are as follows:

- **Study Authorizations –** On August 30, 1935, in the Rivers and Harbors Bill, an initial amount of Federal funds was authorized for constructing Kennett (now Shasta) Dam. Initial authorization for the SLWRI derives from Public Law 96-375 of 1980. This law authorized the Secretary of the Interior to engage in feasibility studies relating to (1) enlarging Shasta Dam and Reservoir, or constructing a replacement dam on the Sacramento River and (2) using the Sacramento River to convey water from an enlarged dam. Additional guidance is contained in Public Law 108-361 of 2004, which authorized the Secretary of the Interior to carry out "…planning and feasibility studies for projects to be pursued with project-specific study for enlargement of the Shasta Dam in Shasta County…"

- **CALFED PEIS/R and Programmatic ROD –** CALFED was established to "develop and implement a long-term comprehensive plan that would restore ecological health and improve water management for beneficial uses of the Bay-Delta system." The 2000 CALFED PEIS/R and Programmatic ROD (CALFED 2000a) include program goals, objectives, and projects primarily to benefit the Bay-Delta system. The objectives for the SLWRI are consistent with the CALFED Programmatic ROD (CALFED 2000a) for Shasta Dam enlargement, as follows:

  > *Expand CVP storage in Shasta Lake by approximately 300 TAF. Such an expansion will increase the pool of cold water available to maintain lower Sacramento River temperatures needed by certain fish and provide other water management benefits, such as water supply reliability.*

  The CALFED Programmatic ROD has been adopted by various Federal and State agencies as a framework for further consideration. In addition to objectives for potential enlargement of Shasta Dam and Reservoir, the Preferred Program Alternative in the CALFED PEIS/R and Programmatic ROD includes four other potential surface water and various groundwater storage projects to help reduce the gap between water supplies and projected demands. Expanding water storage capacity is critical to the successful implementation of all aspects of the program. Water supply reliability rests on capturing peak flows, especially during wet years. New storage must be strategically located to provide the needed flexibility in the current water system to improve water quality, support fish restoration goals, and meet the needs of a growing population. CALFED Programmatic ROD also includes numerous other projects to help improve the ecosystem functions of the Bay-Delta system. Developed plans should address the goals, objectives, and programs and projects of the CALFED PEIS/R and Programmatic ROD (CALFED 2000a, 2000b).

  CALFED conducted an initial screening of a list of 52 potential surface water storage sites to reduce the number of sites to a more manageable number for more detailed evaluation during project-specific studies

(2000b). CALFED eliminated sites providing less than 200,000 acre-feet storage and those that conflicted with CALFED solution principles, objectives, or policies. Further, based on existing information, CALFED identified some potential surface water storage sites that were more promising in contributing to CALFED goals and objectives and more implementable due to relative costs and stakeholder support. Surface water storage sites recommended by CALFED for subsequent evaluation focused on those with the most potential for helping meet CALFED goals and objectives: Shasta Lake Enlargement, Los Vaqueros Reservoir Enlargement, Sites Reservoir, In-Delta Storage, and development of storage in the upper San Joaquin River Basin (CALFED 2000b) (Figure 1-4).

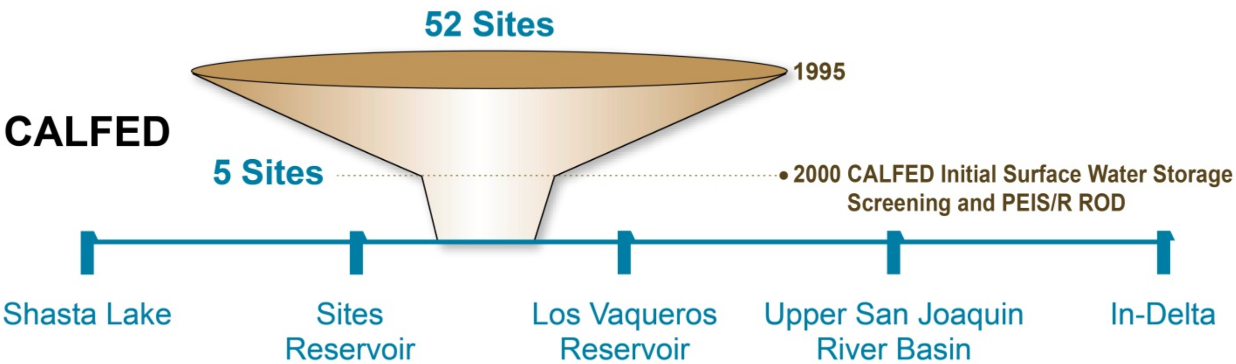


Figure 1-4. CALFED Surface Water Storage Investigations Screening

- **Laws, Regulations, and Policies** – Numerous laws, regulations, executive orders, and policies need to be considered, among them: the P&G, NEPA, Fish and Wildlife Coordination Act, Clean Air Act, Clean Water Act, National Historic Preservation Act, California Public Resources Code, ESA and CESA, California Environmental Quality Act (CEQA), and CVPIA. The CVPIA, including the associated Anadromous Fish Restoration Program, is pertinent because it identified specific actions for fish and wildlife mitigation, protection, restoration, and enhancement which influence water supply deliveries, river flows, and related environmental conditions in the primary and extended study areas. Table 1-4 summarizes many of the applicable laws, policies, plans, and permits potentially affecting the project.

Table 1-4. Summary of Applicable Laws, Policies, Plans, and Permits Potentially Affecting Project

Level	Laws, Policies, Plans, and Permits
Federal	Federal Endangered Species Act
	Section 404 of the Clean Water Act
	Rivers and Harbors Act Section 10
	National Historic Preservation Act, Section 106 (1966)
	Migratory Bird Treaty Act
	Fish and Wildlife Coordination Act
	Executive Orders 11990 (Wetlands Policy), 11988 (Flood Hazard Policy), and 12898 (Environmental Justice Policy)
	Indian Trust Assets
	Americans with Disabilities Act
	Rehabilitation Act
	Farmland Protection Policy
	Federal Transit Administration Activities and Programs
	Essential Fish Habitat
	Architectural Barriers Act
	Federal Cave Resources Protection Act (1988)
	Executive Order 11312 (National Invasive Species Management Plan)
	Magnuson-Stevens Fishery Conservation and Management Act
	National Wild and Scenic Rivers System
	Federal Land Use Policies
	Federal Water Project Recreation Act
	Whiskeytown-Shasta-Trinity National Recreation Area Management Guide
	Whiskeytown-Shasta-Trinity National Recreation Act
	Shasta-Trinity National Forest Management Plan
	Federal Energy Regulatory Commission Permitting Requirements
	U.S. Army Corps of Engineers – Shasta Dam and Reservoir Regulation Requirements
	U.S. Coast Guard Activities and Programs
	Uniform Relocations Assistance and Real Properties Acquisition Act of 1970, as amended (Public Law 91-646 and Public Law 100-17)

Table 1-4. Summary of Applicable Laws, Policies, Plans, and Permits Potentially Affecting Project (contd.)

Level	Laws, Policies, Plans, and Permits
State	California Public Resources Code
	Clean Water Act Section 401
	California Endangered Species Act
	California Fish and Game Code – Fully Protected Species
	California Fish and Game Code Section 1600 – Streambed Alteration
	Porter-Cologne Water Quality Control Act
	California Native Plant Society Species Designations
	Reclamation Board Encroachment Permit
	California Water Rights
	State Lands Commission Land Use Lease
	State of California General Plan Guidelines
	California Department of Transportation Encroachment Permit and Activities, Programs
	California Land Conservation Act of 1965 (Williamson Act)
	California Native Plant Protection Act
	California Department of Boating Activities and Programs
	California Scenic Highway Program
	California Wild and Scenic Rivers Act
Local	Shasta County Air Quality Management District Authority to Construct and Permit to Operate
	Shasta County Building Division Grading Permit
	Shasta County Zone Plan
	Shasta County Department of Public Works Encroachment Permit
	Shasta County General Plan
	Other Local Permits and Requirements

Statewide Water Operation Considerations

Reclamation and DWR use CalSim-II, a specific application of the Water Resources Integrated Modeling System (WRIMS) to Central Valley water operations, to study operations, benefits, and effects of new facilities and operational parameters for the CVP and SWP. Operational assumptions for refinement, modeling, and evaluation of potential effects of the No-Action Alternative and action alternatives included in the EIS were derived from the following:

- The Reclamation 2008 *Biological Assessment on the Continued Long-Term Operations of the CVP and SWP* (2008 Long-Term Operation BA) (Reclamation 2008)
- The USFWS 2008 *Formal ESA Consultation on the Proposed Coordinated Operations of the CVP and SWP* (2008 USFWS BO) (USFWS 2008)
- The NMFS 2009 *BO and Conference Opinion on the Long-Term Operations of the CVP and SWP* (2009 NMFS BO) (NMFS 2009)

- Coordinated Operations Agreement between Reclamation and DWR for the CVP and SWP, as ratified by Congress (Reclamation and DWR 1986)

Despite the uncertainty resulting from ongoing consultation processes, the 2008 Long-Term Operation BA and the 2008 and 2009 BOs issued by the fishery agencies contain the most recent estimate of potential changes in water operations that could occur in the near future. If the revised USFWS and NMFS BOs contain new or amended reasonable and prudent alternatives (RPA), these legal challenges may result in changes to CVP and SWP operational constraints.

Other Planning Considerations

In addition to the planning constraints, a series of other planning considerations helps guide plan formulation, not only in formulating the initial set of concept plans, but also in determining which alternatives best address the planning objectives. Planning considerations relate to economic justification, environmental compliance, technical standards, etc., and may result from local policies, practices, and conditions. Examples of these planning considerations, used in the SLWRI for formulating, evaluating, and comparing concept plans, and later, detailed comprehensive alternatives, include the following:

- Alternative plans should incorporate results of coordination with other Federal and State agencies such as the USFWS, NMFS, USFS, Bureau of Indian Affairs, U.S. Department of the Interior, Bureau of Land Management (BLM), DWR, and California Department of Fish and Wildlife (CDFW).
- A direct and significant geographical, operational, and/or physical dependency must exist between major components of alternatives.
- Alternative plans should address, at a minimum, each of the identified primary planning objectives and, to the extent possible, the secondary planning objectives.
- Measures to address secondary planning objectives should be either directly or indirectly related to the primary planning objectives (i.e., plan features should not be independent increments).
- Alternatives should strive to first avoid potential adverse effects to environmental resources, or then should include features to mitigate for unavoidable adverse effects through enhanced designs, construction methods, and/or facilities operations.
- Alternatives should avoid any increases in flood damage or other significant, adverse hydraulic effects to areas downstream along the Sacramento River.

- Alternatives should strive to first avoid potential adverse effects to present or historical cultural resources, or then include features to mitigate unavoidable adverse effects.

- Alternatives should not result in significant adverse effects to existing and future water supplies, hydropower generation, or related water resources conditions.

- Alternatives should strive to balance increased water supply reliability between agricultural and M&I uses.

- Alternatives should not result in a reduction in existing recreation capacity at Shasta Lake.

- Alternatives are to consider the purposes, operations, and limitations of existing projects and programs and be formulated to not adversely impact those projects and programs.

- Alternatives are to be formulated and evaluated based on a 100-year period of analysis.

- Construction costs for alternatives are to reflect current prices and price levels, and annual costs are to include the current Federal discount rate and an allowance for interest during construction (IDC).

- Alternatives are to be formulated to neither preclude nor enhance development and implementation of other elements included in the CALFED Programmatic ROD or other water resources programs and projects in the Central Valley.

- Alternatives should have a high certainty for achieving intended benefits and not significantly depend on long-term actions (past the initial construction period) for success. Alternatives that require future and ongoing action specific for success have a higher uncertainty than other plans.

Criteria

The Federal planning process in the P&G also includes four specific criteria for consideration in formulating and evaluating alternatives: completeness, effectiveness, efficiency, and acceptability (WRC 1983).

- Completeness is a determination of whether a plan includes all elements necessary to realize planned effects, and the degree that intended benefits of the plan depend on the actions of others.

- Effectiveness is the extent to which an alternative alleviates problems and achieves objectives.

- Efficiency is the measure of how efficiently an alternative alleviates identified problems while realizing specified objectives consistent with protecting the Nation's environment.

- Acceptability is the workability and viability of a plan with respect to its potential acceptance by other Federal agencies, State and local governments, and public interest groups and individuals.

These criteria were used for comparison and evaluation of concept plans (Chapter 4) during the Initial Alternatives Phase, and were used for comparison and evaluation of comprehensive plans in the Final Feasibility Report.

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Chapter 2 Management Measures

After development of the planning objectives, constraints, and criteria, the next major step in formulating concept plans was to identify and evaluate potential management measures. A management measure is any structural or nonstructural project action or feature that could address the planning objectives and satisfies the other applicable planning considerations. Concept plans are formulated (see Chapter 4) by combining retained management measures that address the primary planning objectives.

More than 60 potential management measures were identified as part of the SLWRI plan formulation process to address the primary and secondary planning objectives and satisfy the other applicable planning constraints, considerations, and criteria. These measures were developed through study team meetings, field inspections, public outreach, and environmental scoping for the SLWRI and EIS. Many of these management measures were considered under CALFED. Since the SLWRI EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. While revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required, many of the management measures, including measures not related to the raising of Shasta Dam, were also evaluated during the SLWRI plan formulation process.

Management measures were reviewed by SLWRI study team and stakeholders for their ability to address the primary and secondary planning objectives. Following is a general description of the measures considered, reasons for retaining or deleting the measures from further development, and information on how retained measures could fit into potential concept plans.

In the discussion of SLWRI management measures, the term "enhancement" specifically refers to restoration actions that improve environmental conditions above the baseline (without-project condition). Correspondingly, the term "mitigation" refers to restoration actions that improve environmental conditions toward the baseline to compensate for project impacts. The relationship between enhancement and mitigation is illustrated in Figure 2-1.

Identified management measures were analyzed in the *Mission Statement Milestone Report* (Reclamation 2003a), *Initial Alternatives Information Report* (Reclamation 2004a), and *Ecosystem Restoration Opportunities Report* (Reclamation 2003b) and summarized herein, to determine whether they would be retained for further consideration. One important factor was the potential for a measure to directly address a planning objective without adversely impacting other objectives. Measures were rated on a scale of high to low based on their relative ability to address the planning objectives. In most cases, measures that were rated as moderately addressing a planning objective, or less than moderately, were deleted from further consideration, while measures rating higher were retained. This is primarily because measures that could only marginally address an objective were generally found inconsistent with study constraints or other principles and criteria. Other major factors and rationale in retaining or deleting a measure are included in the following descriptions of the individual management measures.

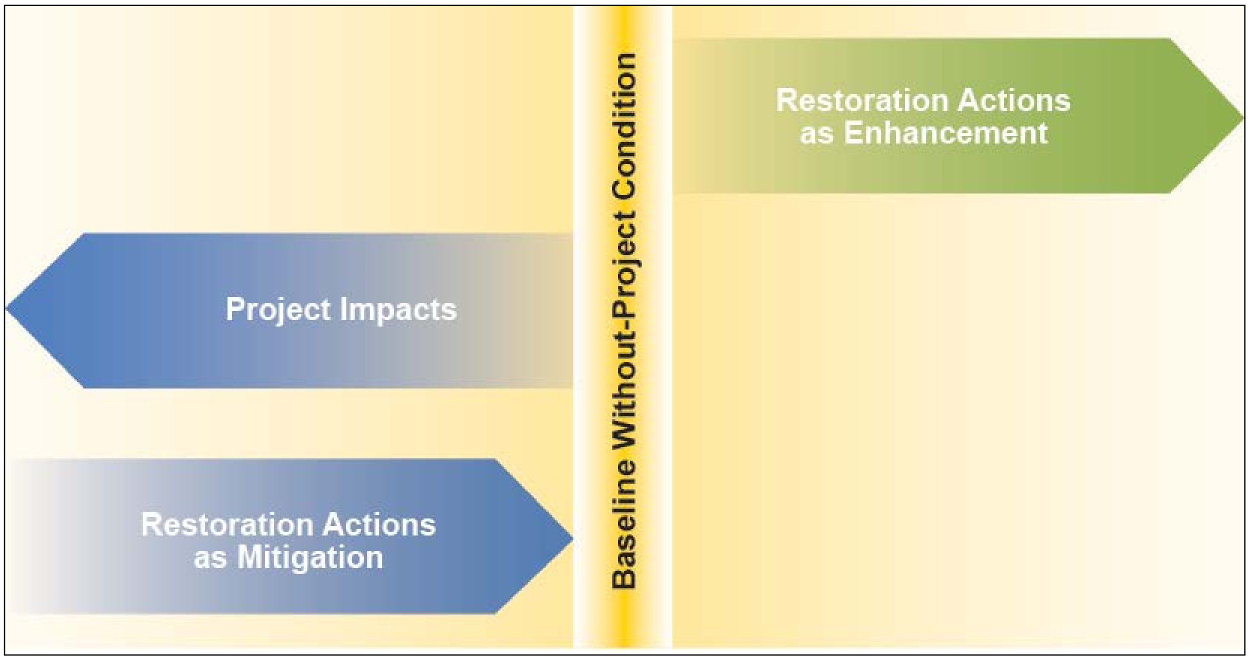

Figure 2-1. Conceptual Schematic of Restoration Actions as Enhancement Versus Restoration Actions as Mitigation

It should be noted that measures that did not directly address the planning objectives, or were otherwise dropped from consideration and further development as alternative plan components under certain circumstances, may be incorporated into alternative plans as mitigation measures. This is primarily because some measures may be found potentially effective in mitigating adverse impacts.

Measures to Address Primary Planning Objectives

Various management measures were identified to address the primary planning objectives of increasing anadromous fish survival and increasing water supply reliably. For each planning objective, measures were identified and separated into categories. In the following sections, rationale is discussed for retaining or deleting each measure.

Increase Anadromous Fish Survival

A number of potential management measures were identified to address increasing anadromous fish survival and other ecosystem restoration opportunities, above and beyond implementation of actions identified in the CVPIA and Anadromous Fish Restoration Program. Most are listed in the November 2003 *Ecosystem Restoration Office Report* (Reclamation 2003b). Of more than 20 measures identified specifically to address the primary objective of increasing anadromous fish survival on the Sacramento River (see Table 2-1), six were retained for possible inclusion in concept plans during the initial plans phase.

Many of the management measures considered under the SLWRI to address increasing anadromous fish survival are encompassed under the Ecosystem Restoration Program (ERP), which was included as part of the CALFED Preferred Program Alternative. The goal of the CALFED ERP is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta system to support sustainable populations of diverse and valuable plant and animal species. The CALFED ERP includes multiple actions to meet this goal, including (1) protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed (which includes the Sacramento River and its tributaries), (2) modifying or eliminating fish passage barriers, including the removal of some dams, construction of fish ladders, and construction of fish screens that use the best available technology, and (3) restoring aspects of the sediment regime by relocating in-stream and floodplain gravel mining, and by artificially introducing gravels to compensate for sediment trapped by dams. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration, $46 million in riparian habitat restoration, $103.1 million for fish screens, and $42.9 million for fish passage (DFG et al. 2010).

Measures Considered

Following is a brief discussion of the array of measures considered, which are separated into three broad categories: (1) improve fish habitat, (2) improve water flows and quality, and (3) improve fish migration. This section summarizes rationale for deleting measures or retaining measures for further consideration, as presented in Table 2-1.

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Table 2-1. Management Measures Addressing the Primary Planning Objective of Increasing Anadromous Fish Survival

Management Measure	Potential to Address Planning Objective	Status/Rationale
Improve Fish Habitat		
Restore abandoned gravel mines along the Sacramento River	**Moderate** – Addresses primary planning objective.	**Deleted –** Consistent with other anadromous fish programs and with secondary planning objectives and constraints. This measure was initially retained, then deleted from further consideration during the comprehensive plans phase due to subsequent modeling results indicating marginal benefits to anadromous fish and a general lack of interest from the public and stakeholders. Encompassed within actions evaluated and prioritized under CALFED ERP.
Construct instream aquatic habitat downstream from Keswick Dam	**Moderate –** Addresses primary planning objective.	**Retained –** This measure was retained for potential further development due to its potential to successfully address the first primary planning objective, potential to combine favorably with other potential measures, and a high interest from fisheries agencies. Encompassed within actions evaluated and prioritized under CALFED ERP.
Replenish spawning gravel in the Sacramento River	**Moderate –** Addresses primary planning objective.	**Retained –** High potential for combining with other measures. Demonstrated benefits that continue as gravel moves downstream. Low initial cost. Concerns over induced downstream impacts to agricultural facilities. Consistent with Federal planning objectives and principles. Encompassed within actions evaluated and prioritized under CALFED ERP.
Construct instream fish habitat on tributaries to the Sacramento River	**Low to Moderate** – Indirectly benefits planning objective.	**Deleted –** Considerable benefit to tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Remove instream sediment along Middle Creek	**Low** – Indirectly benefits planning objective.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. High uncertainty due to increased need for long-term remediation. Encompassed within actions evaluated and prioritized under CALFED ERP.
Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks	**Low** – Indirectly benefits planning objective.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Improve Water Flows and Quality		
Make additional modifications to Shasta Dam for temperature control	**Moderate to High** – Potential to contribute to planning objective by improving temperatures for anadromous fish.	**Retained –** High likelihood of combining with measures involving increasing Shasta storage. Although existing TCD at Shasta effectively meets objectives, potential may exist to further modify the device to benefit anadromous fish with increased storage at Shasta.
Enlarge Shasta Lake cold-water pool	**Moderate to High** – Directly contributes to planning objective by improving water temperature conditions for anadromous fish.	**Retained –** High potential for combining with other measures. Consistent with other primary planning objective and secondary planning objectives. Consistent with goals of CALFED.
Modify storage and release operations at Shasta Dam	**Moderate to High** – Directly contributes to planning objective by improving flow conditions for anadromous fish.	**Retained –** This measure was retained because it is consistent with goals of CALFED and other programs/projects to benefit anadromous fish and has potential to combine with other measures, including raising Shasta Dam and Shasta Reservoir.
Modify Anderson-Cottonwood Irrigation District diversions to reduce flow fluctuations	**Moderate** – Reduced flow fluctuations would benefit anadromous fish, directly contributing to the planning objective.	**Deleted –** Potential modified operations include not installing diversion dam flash boards in spring or not removing flashboards in the late summer/fall. Non-installation would conflict with other primary planning objective of water supply reliability. Non-removal would potentially conflict with the secondary objective of flood damage reduction. Encompassed within actions evaluated and prioritized under CALFED ERP.
Increase instream flows on Clear, Cow, and Bear creeks	**Low** – Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Independent of hydraulic/hydrologic conditions in upper Sacramento River. Would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. Encompassed within actions evaluated and prioritized under CALFED ERP.
Construct a storage facility on Cottonwood Creek to augment spring instream flows	**Very Low** – Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Independent of hydraulic/hydrologic conditions in upper Sacramento River. Adverse environmental impacts expected to exceed benefits. Evaluated during the CALFED alternative development process.

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Table 2-1. Management Measures Addressing the Primary Planning Objective of Increasing Anadromous Fish Survival (contd.)

Management Measure	Potential to Address Planning Objective	Status/Rationale
Improve Water Flows and Quality (contd.)		
Transfer existing Shasta Reservoir storage from water supply to cold-water releases	**Low** – Potential to benefit anadromous fish but at a considerable disbenefit to water supply reliability.	**Deleted –** Violates basic plan formulation criteria – causes considerable reduction in water supply reliability without development of a replacement supply.
Remove Shasta Dam and Reservoir	**Very Low** – Relatively low potential benefit to anadromous fish with major adverse impacts to all other planning objectives.	**Deleted –** Violates basic plan formulation criteria – causes considerable reduction in water supply reliability. No known project or projects could replace the lost benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities, at any price.
Improve Fish Migration		
Improve fish trap below Keswick Dam	**Low to Moderate –** Directly contributes to planning objective by reducing mortality and supplying more fish to hatcheries.	**Deleted –** Although helps fish populations, would not contribute to favorable conditions for sustained spawning and rearing of anadromous fish along mainstem Sacramento River.
Screen diversions on Old Cow and South Cow creeks	**Moderate –** Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Remove or screen diversions on Battle Creek	**Moderate –** Indirectly benefits planning objective on the Sacramento River.	**Deleted –** Considerable benefit to spawning conditions in tributaries. Independent of hydraulic/hydrologic conditions in upper Sacramento River and would not contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Construct a migration corridor from the Sacramento River to the Pit River	**Low –** High uncertainty as to the potential to successfully benefit area resources.	**Deleted –** Volitional fish passage above Shasta Dam is being studied under a separate Federal program as the result of the 2009 NMFS Biological Opinion.
Cease operating or remove the Red Bluff Diversion Dam	**Moderate –** Potential to improve fish migration along upper Sacramento River.	**Deleted –** As the result of another Federal investigation, the Red Bluff Diversion Dam Fish Passage Improvement Project, Reclamation has subsequently ceased operation of Red Bluff Diversion Dam.
Reoperate the CVP to improve overall fish management	**Low –** Limited potential to improve anadromous fish survival along the upper Sacramento River.	**Deleted –** See above measure regarding the Red Bluff Diversion Dam. Issues regarding reoperating facilities on the Trinity River were addressed in the Trinity River Record of Decision in 2000. Any further modification within that system would violate planning criteria for SLWRI through reducing water supply reliability without development of a replacement supply.
Construct a fish ladder on Shasta Dam	**Very Low –** Very low potential for marginal benefit to anadromous fish on the upper Sacramento River.	**Deleted –** Volitional fish passage above Shasta Dam is being studied under a separate Federal program as the result of the 2009 NMFS Biological Opinion.
Reintroduce anadromous fish to areas upstream from Shasta Dam	**Moderate –** Moderate potential for marginal benefit to anadromous fish on the upper Sacramento River.	**Deleted –** Non-volitional fish passage above Shasta Dam is being studied under a separate Federal program as the result of the 2009 NMFS Biological Opinion.

Key:
CALFED = CALFED Bay-Delta Program
cfs = cubic feet per second
CVP = Central Valley Project
TCD = temperature control device

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Improve Fish Habitat The six measures described below were identified to improve fish habitat.

- **Restore abandoned gravel mines along the Sacramento River –** Instream gravel mining has resulted, in many instances, in the degradation of aquatic and floodplain habitat. This is primarily because these activities have often created large artificial pits at various locations in the primary study area that disrupt natural geomorphic processes and riparian regeneration. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality due to stranding and unnatural predation occurs in many abandoned pits that either lose their connections with the river during low-flow periods or otherwise discourage effective transmission of fish passage between the river and mine area. The river cannot refill and restore many of these pits naturally because of changes in flow regime and reductions in coarse sediment input. This measure consists of acquiring, restoring, and reclaiming several inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Gravel pit restoration would involve filling deep depressions and recontouring the stream channel and floodplain within the gravel mine area, if possible and practical, to mimic more natural conditions. Side channels and other features could be created to encourage spawning and rearing and prevent stranding. Soil may need to be imported to replenish areas where gravel mining has resulted in a considerable loss of fine sediments. Revegetation using native riparian plants would be performed on restored floodplain lands.

  This measure was retained for potential further development as part of the SLWRI because it may have potential to successfully address the first primary planning objective. Furthermore, it may combine favorably with other potential measures related to Shasta Dam and Lake and their operation. This measure would not be expected to conflict with other known programs or projects on the upper Sacramento River. Further, the ERP has evaluated, prioritized, and funded ecosystem restoration actions identified in the CALFED Preferred Program Alternative. This measure and similar activities were encompassed in the ERP action related to restoring aspects of the sediment regime by relocating in-stream and floodplain gravel mining, and by artificially introducing gravels to compensate for sediment trapped by dams. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration (DFG et al. 2010).

- **Construct instream aquatic habitat downstream from Keswick Dam –** Keswick Dam is the uppermost barrier to anadromous fish migration on the Sacramento River. Releases from the dam have scoured the channel, and the dam blocks passage of gravels, bed sediments, and woody debris that were replenished historically by upstream tributaries. As a result, aquatic habitat is poor for spawning and rearing of anadromous fish, and predation can be high because of the lack of instream cover. Despite these unfavorable channel conditions, cold-water releases from Keswick Dam attract large numbers of spawners to this reach. This measure consists of constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam to encourage use of this reach by anadromous fish for reproduction. This measure and similar activities were encompassed in the ERP action related to protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, (which includes the Sacramento River and its tributaries). Habitat restoration would involve acquiring lands adjacent to the Sacramento River; earthwork along the riverbank to construct side channels for spawning; and strategic placement of instream cover structures within the river channel, including large boulders, anchored root wads, and other natural materials. Side channels and other features could also be created to encourage spawning and rearing. Restored floodplain lands could be revegetated with native riparian plants.

This measure was retained for potential further development as part of the SLWRI, because it may have potential to successfully address the first primary planning objective and due to high interest from fisheries agencies. Furthermore, this measure will likely combine favorably with other potential measures related to Shasta Dam and Reservoir and their operation. This measure would not be expected to conflict with other known programs or projects on the upper Sacramento River.

- **Replenish spawning gravel in the Sacramento River –** Historically, tributary watersheds upstream from Keswick and Shasta Dams provided a continuous source of high-quality gravel and other coarse sediments to the Sacramento River. Dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Gravel suitable for spawning has been identified as a considerable influencing factor in the recovery of anadromous fish populations in the Sacramento River. Several programs, including CALFED ERP and the Anadromous Fish Restoration Program, have provided gravel replenishment in selected locations. With the exception of the CVPIA(b)(13) program, these programs represent single applications at discrete locations. Similarly, this measure consists of a single application of spawning-sized gravel at a discrete location in the Sacramento River between Keswick and RBPP. Gravel would be transported and placed into the Sacramento River downstream from Keswick Dam.

  This measure was retained for potential further development as part of the SLWRI because it may have potential to successfully address the first primary planning objective. Furthermore, it may combine favorably with other potential measures related to Shasta Dam and Reservoir and their operation.

- **Construct instream fish habitat on tributaries to the Sacramento River –** This measure consists of improving instream aquatic habitat along the lower reaches of tributaries to the Sacramento River. Various structural techniques would be employed to trap spawning gravels in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Both perennial and intermittent streams would be potential candidates for structural habitat improvements. Candidates for aquatic habitat improvement include Middle, Olney, Churn, and Cow creeks. However, this measure would not directly contribute to improved ecological conditions or fish habitat along the mainstem Sacramento River.

  Hydrologic and hydraulic conditions on these tributaries are independent of upper Sacramento River conditions. Habitat conditions in these tributaries would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

  Although this measure would have considerable benefits for tributaries, it was deleted from further development as part of the SLWRI primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration (DFG et al. 2010).

- **Remove instream sediment along Middle Creek** – This measure consists of implementing a sediment removal and control program along Middle Creek, an intermittent tributary to the Sacramento River between Keswick Dam and Redding. Lower Middle Creek supports spawning runs of rainbow trout, steelhead, and salmon. Spawning gravels have been degraded by fine granitic sediment eroding from streambanks and adjacent land. Sediment from the creek also negatively impacts spawning habitat in the Sacramento River around the Middle Creek confluence. However, this measure would not directly contribute to improved ecological conditions or fish habitat along the mainstem Sacramento River.

Hydrologic and hydraulic conditions on these tributaries are independent of upper Sacramento River conditions. Habitat conditions in these tributaries would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

This measure was deleted from further development primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along the mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration (DFG et al. 2010).

- **Rehabilitate inactive instream gravel mines along Stillwater and Cottonwood creeks –** This measure consists of rehabilitating ecological conditions in former instream gravel mining sites along Stillwater Creek. Seven inactive gravel pits on Stillwater and/or Cottonwood creeks historically contributed to depletion of nearly all instream gravel resources along various reaches, leaving the channel scoured to bedrock. Restoring these gravel mines could help Stillwater Creek provide additional seasonal habitat for various anadromous and resident fish. However, this measure would not directly contribute to improved ecological conditions or fish habitat along the mainstem Sacramento River.

  Hydrologic and hydraulic conditions on these tributaries are independent of upper Sacramento River conditions. Habitat conditions in these tributaries would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

This measure was deleted from further development primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along the mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. This measure and similar activities were encompassed in the ERP action related to restoring aspects of the sediment regime by relocating in-stream and floodplain gravel mining, and by artificially introducing gravels to compensate for sediment trapped by dams. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration (DFG et al. 2010).

Improve Water Flows and Quality The following section describes the measures considered for improving water flows and quality.

- **Make additional modifications to Shasta Dam for temperature control –** The TCD installed at Shasta Dam allows operators to make selective releases from various reservoir depths to regulate water temperatures to benefit anadromous fish in the upper Sacramento River. This measure consists of determining if making additional structural modifications to the outlets and existing TCD for temperature control is possible and feasible and, if so, implementing those modifications.

  This measure was retained for further development primarily because it could (1) improve the performance of the existing facility, (2) complement other measures under consideration to raise Shasta Dam, and (3) complement measures to improve aquatic spawning habitat in the Sacramento River. This measure would not conflict with other ecosystem restoration measures preliminarily retained herein, or other known programs or projects on the upper Sacramento River.

- **Enlarge Shasta Lake cold-water pool –** Cold water released from Shasta Dam considerably influences water temperature conditions on the Sacramento River between Keswick Dam and the RBPP. This measure consists of enlarging the cold-water pool by either raising Shasta Dam and enlarging the minimum operating pool, or increasing the seasonal carryover storage in Shasta Lake. Each action would help provide greater flexibility in meeting water temperature targets throughout the year and extending suitable spawning habitat downstream. This measure also would be consistent with the goals of CALFED.

This measure was retained for further development primarily because it would (1) directly contribute to both primary planning objectives for the SLWRI, (2) combine favorably with other measures, and (3) have a high certainty of providing the intended benefits once implemented. This measure would not conflict with any other ecosystem restoration measures that were preliminarily retained. Further, the CALFED Preferred Program Alternative recommended project specific study of expanding CVP storage in Shasta Lake to increase the pool of cold water available to maintain lower Sacramento River temperatures needed by certain fish and provide other water management benefits, such as water supply reliability.

- **Modify storage and release operations at Shasta Dam –** In addition to water temperature, flow conditions in the upper Sacramento River are also important in addressing anadromous fish needs. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries. Although this measure could help provide greater flexibility in meeting water temperature targets, it would be aimed primarily at improving flows and influencing physical channel conditions for anadromous fish. Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas and to improve the quality of aquatic habitat. The quality of aquatic habitat could be further improved by cleaning spawning gravels. These changes would be at the discretion of Reclamation based on recommendations by the Sacramento River Temperature Task Group (SRTTG). This measure would be consistent with the goals of the Anadromous Fish Restoration Program included as part of the CVPIA. This measure also could include release changes during the flood season to permit "pulse flows" and other releases that could improve aquatic habitat conditions. Further, this measure could provide additional control and dilution of acid mine drainage from Spring Creek.

  This measure was initially deleted from consideration because analyses indicated a decreased fisheries benefit with increasing Sacramento River flows compared to increasing the cold-water pool. However, this measure was retained for further development when combined with additional storage space in Shasta Reservoir, as part of an adaptive management plan, primarily because it could directly contribute to both primary objectives of the SLWRI and combine favorably with other measures.

- **Modify Anderson-Cottonwood Irrigation District diversions to reduce flow fluctuations –** This measure consists of modifying operations at the Anderson-Cottonwood Irrigation District diversion dam near Anderson to reduce extreme flow fluctuations and their resulting impacts on anadromous fish. Extreme fluctuations in Sacramento River flows result in fish stranding and juvenile fish mortality. Releases from Keswick Dam are temporarily reduced in the spring, to safely install flash boards on the diversion dam, and in the late summer/early fall, to safely remove the flash boards. Modified operations would include either not installing the flash boards in spring or not removing the flash boards in late summer/fall. If flash boards were not installed, Anderson-Cottonwood Irrigation District's ability to divert and deliver water supplies through their gravity canal system would be reduced. If flash boards were not removed in the fall, this would increase Sacramento River water levels upstream from the diversion dam during the flood season and increase the likelihood of flood damage.

This measure was deleted from further development, however, primarily because of potential impacts to water supply reliability. Negative impacts on water deliveries from the Anderson-Cottonwood Irrigation District diversion dam would conflict with the second primary planning objective of increasing water supply reliability. This measure would also potentially conflict with the secondary objective of flood damage reduction. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration and $42.9 mission for fish passage (DFG et al. 2010). Structural modifications to Anderson-Cottonwood Irrigation District's diversion dam could be accomplished through the CALFED ERP.

- **Increase instream flows on Clear, Cow, and Bear creeks –** This measure consists of increasing instream flows on Clear, Cow, and Bear Creeks during critical periods to support anadromous fish that spawn in the creek. Increasing flows would improve the quality of spawning habitat and help reduce water temperatures, thereby increasing the amount of suitable tributary spawning habitat available in the creeks.

  This measure was deleted from further development primarily because it would not contribute directly to increasing anadromous fish survival within the primary Sacramento River study area. In addition, this measure could impact hydropower production. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration (DFG et al. 2010).

- **Construct a storage facility on Cottonwood Creek to augment spring instream flows –** This measure consists of constructing a dry dam or offstream storage facility on upper Cottonwood Creek to support flows for spring-run Chinook salmon. A storage facility would allow late-spring and summer releases for spring-run Chinook salmon, and improve overall seasonal aquatic conditions.

  This measure was deleted from further development primarily because it is an independent action. It would not considerably or directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. In addition, it is highly likely that this measure would have considerable and overriding adverse environmental impacts in the Cottonwood Creek watershed. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

- **Transfer existing Shasta Reservoir storage from water supply to cold-water releases –** This measure consists of reoperating the existing Shasta Dam and Reservoir for anadromous fishery resources. This measure was requested as part of the environmental scoping process. For this measure, it was assumed that storage space in Shasta could be reoperated to provide flows similar to those identified in the January 2001 *Final Restoration Plan* for the Anadromous Fish Restoration Program. This would require an optimal minimum flow along the upper Sacramento River of about 5,500 cubic feet per second (cfs) during certain periods of time. Operational considerations of the increased flows would be given to managing the existing cold-water pool in Shasta Reservoir. Although a portion of the cold-water releases could be diverted downstream for water supply, the overall effect would be a reduction in agricultural and M&I water supply deliveries. A cursory estimate was made of the potential water supply delivery reduction through increasing the minimum flows from the existing 3,250 cfs to 5,500 cfs. It showed that the loss in dry and critical year water deliveries would amount to about 50,000 acre-feet per year. Additional fishery modeling studies and water supply related analysis would be necessary to both confirm the magnitude of decreased water supplies for agricultural and M&I deliveries and potential benefit to the anadromous fishery.

This measure was deleted from further consideration primarily because it violates at least one of the planning criteria concerning the potential to adversely impact existing project purposes, by reducing existing water supplies for agricultural and M&I deliveries. Further, this measure would adversely impact the primary objective related to increasing agricultural and M&I water supply reliability. Although this measure specifically evaluated transferring existing storage space to cold-water releases, the concept of increasing cold-water releases from an enlarged Shasta Dam and Reservoir was evaluated during formulation of the comprehensive plans.

- **Remove Shasta Dam and Reservoir –** This measure consists of removing the existing Shasta Dam and Reservoir to benefit anadromous fishery resources. This measure was requested as part of the environmental scoping process. It is believed that this measure would also include removing Keswick Dam and Reservoir to allow anadromous fish to access upstream river areas. Removing Keswick and Shasta Dams and Reservoirs would allow anadromous fish access to spawning areas that are now within the lake areas and passage to the headwaters of the upper Sacramento River, several smaller streams, and about 24 miles of river area along the lower McCloud River. A number of additional dams and reservoirs on the Pit and upper McCloud rivers would block access along those water courses.

  The Shasta Division of the CVP provides supplemental irrigation service to nearly 1 half-million acres of land in the Central Valley of California. It also provides water for M&I purposes and power generation amounting to about 680,000 kilowatts. In addition, Shasta Dam helps reduce flooding over a large area along the Sacramento River. Estimates of flood damages prevented by Shasta Dam and Reservoir during the major storms of 1995 and 1997 were about $3.5 billion and 4.3 billion, respectively. Much of the economy of the Central Valley, and the entire State, has greatly benefited from Shasta Dam and Reservoir. It is believed that the cost of Shasta Dam and Reservoir and its associated facilities have been paid multiple times over since they were constructed in the early 1940s. Although the potential benefit to anadromous fish resources along the upper Sacramento River may be sizeable (substantial studies would be required to define potential benefits and disadvantages to the fisheries), these benefits by no means begin to approach the monetary benefit associated with the existing project. No known project or projects could replace the benefits provided by Shasta and Keswick dams, reservoirs, and appurtenant facilities at any price.

  This measure was deleted from further consideration primarily because it violates at least one of the planning criteria concerning the potential to adversely impact existing project purposes.

Improve Fish Migration The measures identified to improve migration are described in the subsequent section.

- **Improve fish trap below Keswick Dam –** Keswick Dam is an upstream barrier to fish migration on the Sacramento River. As part of mitigation actions associated with the construction of Shasta and Keswick dams, a fish trap facility was constructed at Keswick Dam to capture anadromous fish for transport to the Coleman National Fish Hatchery on Battle Creek. This measure consists of improving the efficiency and performance of the fish trap below Keswick Dam to increase survival of anadromous fish captured at the facility, thereby providing additional adults and increased egg production for fish hatchery operations. Although this measure has potential to contribute to the primary planning objective of increasing anadromous fish populations in the upper Sacramento River, it would not necessarily contribute to increasing survival of anadromous fish in the upper Sacramento River.

  This measure was deleted from further development primarily because it would not improve spawning and rearing conditions necessary for natural and sustainable reproduction of anadromous fish in the upper Sacramento River.

- **Screen diversions on Old Cow and South Cow creeks –** This measure consists of screening diversion intakes in the Cow Creek watershed to reduce fish mortality. Over 100 agricultural diversions exist from the Cow Creek watershed; while many are small, larger diversions can entrain juvenile salmonids and other fish that use spawning habitat provided by the watershed. This measure would potentially reduce salmonid mortality at diversions within the Cow Creek watershed. However, several programs, including the CVPIA (b)(21), are already proceeding with installation of fish screens within the Sacramento River system. Furthermore, this measure would not contribute directly to improved fish migration in the upper Sacramento River. Some of the largest diversions identified as part of this measure, such as Kilarch Powerhouse Ditch, South Cow Creek Powerhouse Ditch, and Bassett Ditch, are between 10 and 25 miles upstream from the confluence with the Sacramento River.

  Hydrologic and hydraulic conditions on these tributaries are independent of upper Sacramento River conditions. Habitat conditions in these tributaries would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

This measure was deleted from further development primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along the mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes modifying or eliminating fish passage barriers, including the removal of some dams, construction of fish ladders, and construction of fish screens that use the best available technology (CALFED 2000a). The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $103.1 million for fish screens and $42.9 million for fish passage (DFG et al. 2010).

- **Remove or screen diversions on Battle Creek –** This measure consists of removing or screening diversions and other water control facilities on Battle Creek to allow full use of the watershed's high-quality, cold-water spawning habitat. Several projects either have been, or are being implemented, on Battle Creek to improve access to habitat and spawning success, including the Battle Creek Salmon and Steelhead Restoration project and the Orwick Diversion Fish Screen Improvement Project. However, additional large portions of the upper Battle Creek watershed remain inaccessible to anadromous fish because of diversions. This measure would provide access to high-quality spawning habitat in the upper Battle Creek watershed. However, several programs, including the CVPIA (b)(21) are already proceeding with installing fish screens within the Sacramento River system. Furthermore, this measure would not contribute directly to improved fish migration in the upper Sacramento River.

  Hydrologic and hydraulic conditions on these tributaries are independent of upper Sacramento River conditions. Habitat conditions in these tributaries would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

  This measure was deleted from further development primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes modifying or eliminating fish passage barriers, including the removal of some dams, construction of fish ladders, and construction of fish screens that use the best available technology (CALFED 2000a). The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $103.1 million for fish screens and $42.9 million for fish passage (DFG et al. 2010).

- **Construct a migration corridor from the Sacramento River to the Pit River –** This measure consists of providing passage to spawning areas upstream from Shasta Dam for anadromous fish from the Sacramento River. One concept includes connecting the upper Pit River to the Sacramento River, which would consist of (1) constructing a fish channel between the Cow Creek basin and the Pit River Arm of Shasta Lake, (2) constructing a fish barrier to prevent fish from entering Shasta Lake, and (3) installing fish screens and flow control structures at various locations along the natural and man-made migration route to prevent straying.

  This and similar measures were initially deleted from further consideration during earlier phases of the SLWRI primarily because of the (1) high cost for complex infrastructure, (2) major impacts to other facilities and extensive long-term operation and maintenance requirements, and (3) high uncertainty for the potential to achieve and maintain successful fish passage and spawning. However, Reclamation is currently studying volitional fish passage above Shasta Dam under a separate Federal program as the result of the 2009 NMFS BO.

- **Cease operating or remove the Red Bluff Diversion Dam –** This measure involved either ceasing the operation of Red Bluff Diversion Dam or removing the facility completely. This measure was requested as part of the environmental scoping process. The two primary fish passage issues associated with the Red Bluff Diversion Dam were (1) delay and blockage of adults migrating upstream, and (2) the impedance and losses of juveniles emigrating downstream. Fish ladders located on each abutment of the dam were ineffective, limiting access to remaining spawning habitat between Keswick Dam and Red Bluff. Predation was also problematic in Lake Red Bluff. Potential solutions to these problems were considered as part of the Red Bluff Diversion Dam Fish Passage Improvement Project, a cooperative effort led by Reclamation and the Tehama-Colusa Canal Authority. The project developed a long-term solution to relieve conflicts between fish passage and agricultural diversion needs. A number of alternatives were considered, including removing the barrier to fish by removing the gates completely and constructing pumps to divert water into the Tehama-Colusa Canal, improvements to the existing fish ladders, and construction of a bypass channel.

This measure was deleted from further consideration in the SLWRI because, as the result of the Red Bluff Diversion Dam Fish Passage Improvement Project, Reclamation has subsequently ceased operation of Red Bluff Diversion Dam.

- **Reoperate the CVP to improve overall fish management –** This measure primarily includes reoperating all of the CVP facilities in the upper Sacramento River system to improve anadromous fish resources. This measure was requested as part of the environmental scoping process. Major CVP facilities in the Sacramento River watershed that could influence the primary planning objective besides Shasta Dam and Reservoir includes Keswick Dam and Reservoir and features of the Trinity and Sacramento River Divisions. Major facilities in the Trinity River Division include Trinity Dam and Trinity Lake on the Trinity River, Lewiston Dam and Lake on the Trinity River, and Whiskeytown Dam and Lake on Clear Creek. Major facilities in the Sacramento River Division include the RBPP and various facilities within the Corning and Tehama-Colusa Canal service areas.

  Historically, following construction of the Trinity River Division of the CVP, Reclamation diverted up to 90 percent of the flow of the Trinity River to the Sacramento River. At the end of 2000, the U.S. Department of the Interior signed the Trinity River ROD (Reclamation 2000) authorizing a variable instream flow regime and habitat restoration projects to improve fishery conditions on the Trinity River. Any further reoperation of the facilities within the Trinity River Division to provide additional water for fish in the Sacramento River could likely only be accomplished at the expense of fish on the Trinity River. In addition, as a result of the Red Bluff Fish Passage Improvement Project, Reclamation ceased operating Red Bluff Diversion Dam to improve fish passage conditions in the Sacramento River. Construction of a screened pumping plant, the RBPP, was completed in 2012 to provide for continued water deliveries within the Corning and Tehama-Colusa Canal CVP service areas.

  This measure was deleted from further consideration in the SLWRI primarily because no opportunity appears to exist to effectively further reoperate the CVP facilities capable of affecting the Sacramento River that would not result in adversely impacting other project purposes.

- **Construct a fish ladder on Shasta Dam** – This measure primarily includes constructing a fish ladder on Shasta Dam to allow anadromous fish to access Shasta Lake and approximately 40 miles of the upper Sacramento River, about 24 miles of the lower McCloud River, and various small creeks and streams tributary to Shasta Reservoir. This measure was requested as part of the environmental scoping process. A fish ladder at Shasta Dam would need to be approximately 476 feet high. A number of high-head dams have been studied for fish ladders, many of which would have allowed fish passage to much more historical spawning areas than would be available upstream from Shasta Lake. All of these high-head dam fish ladders have been rejected mainly for cost reasons (fish trapping and hauling is much cheaper under these circumstances). In addition, a high ladder concept was attempted at the Pelton project on the Deschutes River in Oregon. At this location, the fish were not able to travel the entire distance safely because of the extreme length of the ladder, and the water temperature increased considerably at higher elevations.

This measure was initially deleted from further consideration during earlier phases of the SLWRI primarily because of the estimated high cost to construct and operate the fish ladder and potential inability for fish to successfully ascend the ladder. However, Reclamation is currently studying volitional fish passage above Shasta Dam under a separate Federal program as the result of the 2009 NMFS BO.

- **Reintroduce anadromous fish to areas upstream from Shasta Dam** – This measure primarily includes non-volitional fish passage above Shasta Dam, involving trapping anadromous fish along the Sacramento River likely just downstream from Keswick Dam, transporting the fish by tanker truck, and releasing the fish in the upper Sacramento River or the McCloud River to spawn. It would also include some method of trapping potential out-migrating fish and transporting them to the Sacramento River near Keswick for release into the lower river. This measure was requested as part of the environmental scoping process. Numerous dams would preclude this measure on the upper Pit River.

  This measure was deleted from further consideration in the SLWRI primarily because non-volitional fish passage above Shasta Dam to the upper Sacramento and McCloud rivers is being studied under a separate Federal program as the result of the 2009 NMFS BO.

Measures Retained for Further Consideration

Each of the six management measures retained to address the primary planning objective of increasing anadromous fish survival was considered in greater detail to determine how they might become components of potential concept plans. Of the six measures initially retained, five were chosen for further development and inclusion in comprehensive plans. Measures are shown in Figure 2-2, and their major components, accomplishments are described below.

- **Restore abandoned gravel mines along the Sacramento River –** Protecting and restoring spawning and rearing habitat have been identified by National Oceanic and Atmospheric Administration Fisheries as a primary goal in the recovery of Sacramento River winter-run Chinook salmon. It is estimated that over 80 percent of the winter

Chinook spawning population migrates to the upper Sacramento River when passage at the Red Bluff Diversion Dam is unobstructed. Therefore, restoring suitable spawning habitat in the upstream reach of the river has potential to benefit a large portion of the salmonid population.

One method of increasing anadromous fish survival is rehabilitating lands formerly mined for gravel along the Sacramento River. Instream gravel mining degrades aquatic and floodplain habitat by (1) creating large artificial pits along the river that disrupt natural geomorphic processes and riparian regeneration, (2) stranding fish and encouraging predation, and (3) removing valuable gravel sources. Aquatic conditions at former gravel mining sites are typically unsuitable for spawning and rearing. High fish mortality occurs at many abandoned pits that effectively lose their connection with the river during low flow periods, stranding fish and encouraging unnatural predation rates. Because of changes in flow regime and reductions in coarse sediment input, the river is not capable of refilling and restoring many of these pits naturally. In addition, removing fine sediments during the gravel extraction process inhibits establishment of riparian vegetation that provides protective cover and shade for spawning and rearing.

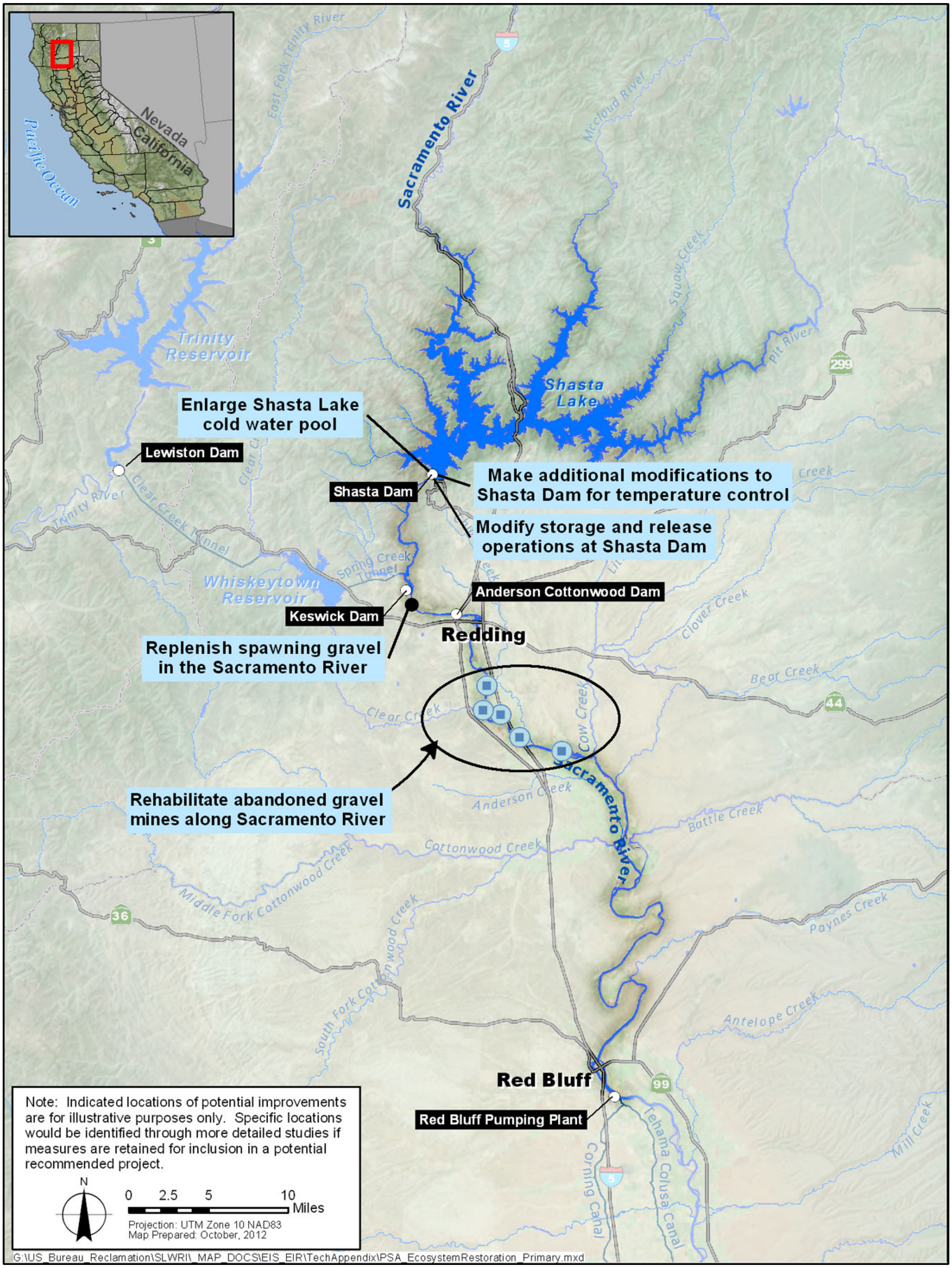

Figure 2-2. Measures Retained to Address Primary Planning Objective – Anadromous Fish Survival

Actions associated with this measure would help restore the natural complexity required for a healthy, self-sustaining river ecosystem. Actions would include filling deep pits (potentially requiring suitable fill material to be imported from local sources), recontouring the stream channel and floodplain to mimic natural conditions, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features could be created to encourage spawning and rearing, and restored floodplain lands could be revegetated using native plants. Soil might need to be imported to replenish areas where gravel mining has resulted in a considerable loss of fine sediments. Hydrologic, hydraulic, and sedimentation studies would identify optimal restoration conditions and any actions necessary to offset or minimize undesirable hydraulic conditions caused by restoration.

This measure consists of acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the Sacramento River to create valuable aquatic and floodplain habitat. Several potential sites for gravel mine restoration along the Sacramento River between Keswick and the RBPP listed in Table 2-2. Figure 2-3 shows an example area for implementing this measure. Most of these sites consist of one or more deep pits surrounded by partially disturbed land, with the majority of sites consisting of disturbed lands that would require minimal restoration actions. For this assessment, however, a potential restoration area of 150 acres was considered. The exact size and location(s) would be determined in further studies.

Table 2-2. Potential Gravel Mine Restoration Sites Along the Sacramento River

Location	Approximate River Mile	Bank	Area acres
Red Bluff near Salt Slough	247	Left	140
Upstream from Stillwater Creek	282	Right	320
Redding	287-288	Right	135
Redding	287.5-288	Left	65
Redding	288.5-290.3	Left	305
Redding	292.5-294	Left	230

Source: M. Kondolf, 1989

Figure 2-3. Example of Abandoned Gravel Mine with Isolated Pits (left side of photo)

Primary accomplishments of gravel mine site restoration along the upper Sacramento River would be to (1) improve spawning success by increasing the amount of suitable spawning habitat along the Sacramento River for anadromous fish and (2) improve the health and vitality of self-sustaining riverside riparian ecosystems by restoring their connection with natural geomorphologic processes.

This measure would support the primary planning objective of increasing the survival of anadromous fish populations in the Sacramento River by eliminating stranding and restoring spawning and rearing habitat at one or more abandoned gravel pits. The measure also would support the secondary planning objective of conserving and restoring ecosystem resources along the upper Sacramento River through restoring riparian and floodplain habitat.

Although this measure was initially retained and considerably developed for inclusion in concept plans, as discussed above, it was later deleted from further development during the comprehensive plans phase. Subsequent evaluations related to the use of the SALMOD model have indicated that restoring these areas may not result in a significant benefit to anadromous fish. Concerns were also expressed that ranged from a low likelihood that these areas could be effectively used to increase spawning and rearing habitats to the likelihood for increased predation. Further, during public and stakeholder outreach meetings in late 2005 held primarily for environmental scoping purposes, there was little to no interest expressed for acquisitioning and restoring these areas. At this time, restoration of abandoned gravel mines is not included in further plan formulation activities for the SLWRI.

- **Construct instream aquatic habitat downstream from Keswick Dam –** This measure consists of constructing aquatic habitat in and adjacent to the Sacramento River downstream from Keswick Dam to encourage use of this reach by anadromous fish for spawning and rearing. Habitat enhancements in this measure included floodplain, riparian, and side channel habitats.

Side channels can support important habitat for anadromous salmonids, including rearing and spawning habitat. Side channel habitats provide refuge from predators and productive foraging habitat for juvenile anadromous salmonids. Salmonids also seem to prefer the hydraulic and channel bed conditions provided in side channels for spawning.

Riparian vegetation, including shaded riverine aquatic cover, provides juvenile salmonids cover from predators, habitat complexity, a source of insect prey, and shade for maintaining water temperatures within suitable ranges for all life stages. Juvenile salmonids prefer riverine habitat with abundant instream and overhead cover (e.g., undercut banks, submerged and emergent vegetation, logs, roots, other woody debris, and dense overhead vegetation) to provide refuge from predators, and a sustained, abundant supply of invertebrate and larval fish prey.

There is an opportunity to perform riparian and floodplain habitat restoration along the Sacramento River downstream from Keswick Dam to promote the health and vitality of the river ecosystem. Locations near tributary confluences that are inundated by floods on a fairly frequent basis would be targeted for restoration to maximize the potential for long-term success and benefits. Restoration would include replacing lost floodplain sediment, regrading or recontouring floodplains that have been disconnected from the river, removing berms or levees (as appropriate), and revegetating floodplain and adjacent riparian areas. Locations for restoration would be in areas with a 20 to 50 percent chance of flooding in any year to ensure riparian habitat growth and regeneration. If the lands chosen for restoration are not already in public ownership, land acquisition and/or easements may be required to implement the measure and ensure continued benefits.

This measure would support the secondary objective to conserve and restore ecosystem resources along the upper Sacramento River by restoring native riparian habitat, side channels, and associated floodplain lands. Riparian habitat also contributes to the quality of instream aquatic habitat, providing shade and a source of woody debris; therefore, this measure may also support the primary study objective to increase the survival of anadromous fish in the Sacramento River.

- **Replenish spawning gravel in the Sacramento River –** The restoration of aquatic habitat between Keswick Dam and the RBPP is of high priority because this stretch is one of the few remaining spawning corridors available to anadromous fish along the Sacramento River. This measure would support the primary objective of increasing the survival of anadromous fish populations in the Sacramento River by contributing to replenishing spawning gravels used by anadromous fish.

Historically, the tributary watersheds upstream from Keswick and Shasta Dams provided a source of gravel and other coarse sediments to the Sacramento River. Gravels were continually replenished as they moved down the river system. Gravel recruitment is of particular importance to anadromous fish, which require clean gravels for their spawning beds. Dams, river diversions, gravel mining, and other obstructions have blocked or reduced natural gravel sources. Suitable spawning gravel has been identified as a potential limiting factor in the recovery of anadromous fish populations on the Sacramento River. Several other programs, including CALFED and the CVPIA, have provided gravel replenishment on the Sacramento River in selected locations.

There are opportunities to replenish spawning gravel in the Sacramento River and along the lower reaches of its tributaries. The reach immediately downstream from Keswick Dam has no natural gravel sources and provides marginal spawning habitat. These gravel sources could be artificially augmented by gravel injections.

This measure would involve transporting and placing gravel into the Sacramento River downstream from Keswick Dam. Actions would include placing suitable gravels into the Sacramento River immediately below Keswick Dam. Structural treatments may be required below Keswick Dam to prevent the gravel from being washed downstream. Temporary construction easements could be required. Suitable spawning gravel would consist of uncrushed, natural river rock, washed and placed in the river at strategic locations. Hydraulic and geomorphic evaluations are needed to determine the most effective gravel size distribution and the most appropriate locations for gravel placement. The size and amount of gravel is first determined by the hydraulic characteristics of the river at the injection site and secondarily by the spawning characteristics of the targeted fish species. For the purpose of this evaluation, it is estimated that a total of 10,000 tons of gravel between 1 inch and 3 inches in diameter would be injected at one site.

Replenishing gravel in relatively stable reaches that lack natural gravel sources, preferably those with complex structures or large woody debris to trap and retain gravel, would increase the success and longevity of the measure. The reach immediately downstream from Keswick Dam has no natural gravel sources and currently provides marginal spawning habitat. Gravel placement would be concentrated in this uppermost reach, between Anderson and Keswick Dam. Gravel is typically moved downstream from the site of placement by high flows that occur, on average, about every 5 years. However, added spawning gravels continue to benefit the stream environment as they move through a river system, although the benefits tend to be less distinct farther downstream.

This measure would support the primary planning objective of increasing the survival of anadromous fish populations in the Sacramento River by restoring spawning gravels in stream channels that no longer have adequate gravel resources. After water temperature, the presence and quality of spawning gravel is probably the most important factor contributing to the reproductive success of anadromous fish.

- **Make additional modifications to Shasta Dam for temperature control –** Adverse water temperature conditions in the upper Sacramento River have been identified as a critical factor leading to decline of anadromous fish species. As demand for CVP water has increased over time, the ability to maintain suitable water temperatures downstream from Keswick Dam for salmonids has become increasingly difficult. The NMFS 1993 BO for CVP and SWP operations (NMFS 1993) established water temperature criteria for the Sacramento River between Keswick Dam and Bend Bridge, or points upstream from Bend Bridge depending on climatic and water storage conditions. These water temperature requirements were reinforced by the subsequent 2004 and 2009 NMFS BOs for CVP and SWP operations. The existing TCD at Shasta Dam, shown in Figures 2-4 and 2-5, was constructed from 1996 to 1998 to help meet requirements of the 1993 BO.

Figure 2-4. TCD Located on Upstream Face of Shasta Dam

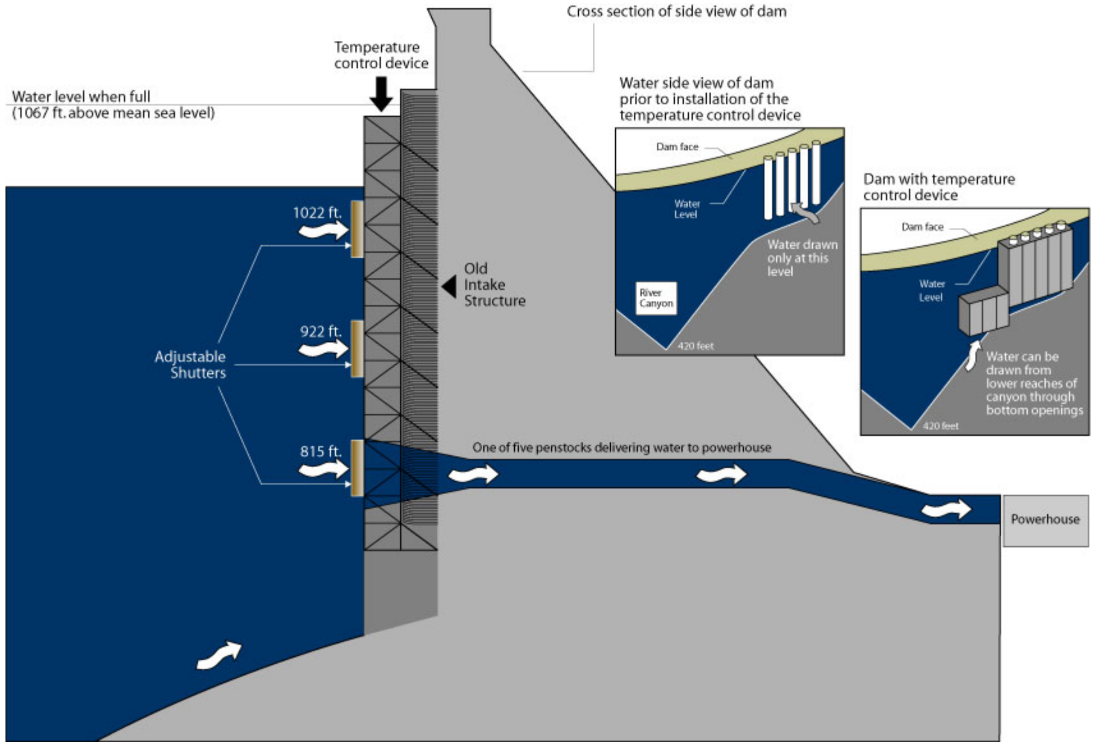

Figure 2-5. Shasta Dam Temperature Control Device

This measure consists of first assessing if modifications to the TCD are possible and feasible and, if so, implementing those modifications. This measure could be highly effective when combined with measures to increase storage space in Shasta Reservoir. For relatively small raises of Shasta Dam, the existing TCD structure would be retrofitted to account for additional dam height and to reduce leakage of warm water into the structure, but no new structure would be needed. However, modifications to the existing structure are more likely to become necessary for increasingly higher dam raises. For dam raises higher than about 50 feet, it is believed that major modifications to the TCD would be needed to manage the increasing depth and volume of water. Accordingly, modifications under this measure for higher dam raises would include widening the existing structure to increase intake capacity, and extending the device to a greater depth. In addition, this measure would provide for added structural modifications to the outlets at Shasta Dam for the purpose of temperature control.

Accomplishments of this measure would be to increase survival of anadromous fish populations in the Sacramento River by (1) increasing the ability of operators at Shasta Dam to meet downstream temperature requirements for anadromous fish, (2) providing more flexibility in achieving desirable water temperatures during critical spawning, rearing, and out-migration, and (3) extending the area of suitable spawning habitat farther downstream in the Sacramento River.

This measure would support the primary planning objective of increasing survival of anadromous fish populations in the Sacramento River. Also, it would complement potential measures to increase storage in Shasta Dam because additional temperature control improvements could be incorporated into the design of a dam raise and further improve cold-water releases. This measure would combine well with measures to improve aquatic spawning habitat in the Sacramento River because better water temperature regulation could allow anadromous fish to take greater advantage of these habitat improvements. This measure would not conflict with other environmental restoration measures or other known programs or projects on the upper Sacramento River.

- **Enlarge Shasta Lake cold-water pool –** Cold water released from Shasta Dam considerably influences water temperature conditions on the Sacramento River between Keswick Dam and the RBPP. This measure includes increasing the volume of the cold-water pool in Shasta Lake by raising Shasta Dam and enlarging Shasta Lake primarily to help maintain colder releases for anadromous fish during certain periods. Increased storage volume could also help increase seasonal flows during dry and critical years in the upper Sacramento River that are important to fish populations.

  Possible operational changes to the timing and magnitude of releases from Shasta Dam, primarily to improve the quality of aquatic habitat, could be applied under an adaptive management plan. Changes in operating the cold-water pool could include increasing minimum flows, timing releases out of Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional water in storage to meet temperature requirements. Reclamation would manage the cold-water pool each year based on recommendations from the SRTTG.

  Dam raises ranging from about 6.5 feet to about 200 feet have been considered in previous studies by Reclamation. A dam raise of about 6.5 feet, as suggested in the CALFED Programmatic ROD, would increase storage by about 256,000 acre-feet. A dam raise of about 200 feet would increase storage by about 9.3 MAF. The increased cold-water pool could be used to meet existing or proposed temperature targets or provide additional cold-water discharges during the summer, which could considerably extend the downstream reach of suitable spawning habitat. Increased volume could also help meet minimum flows in late fall in the upper Sacramento River.

  Raising Shasta Dam and enlarging Shasta Lake would result in impacts to natural resources and infrastructure around the reservoir rim, potentially requiring considerable mitigation and relocations. Impacts associated with dam raises of less than about 18 feet would be significant but likely manageable. Higher dam raises would result in major impacts to reservoir area resources and infrastructure, reducing the likelihood of economic justification. In addition to extreme impacts in the Shasta Lake area, very high dam raises (100 to 200 feet) might also result in major impacts to natural resources along the Sacramento River downstream from the dam. These impacts would likely eliminate serious consideration of high dam raises.

This measure would support the primary planning objective of increasing survival of anadromous fish populations by (1) improving water temperature control, (2) extending suitable spawning habitat, and (3) improving overall physical aquatic habitat conditions in the Sacramento River. It also would support the primary planning objective of increasing water supply reliability. The estimated certainty of this measure in achieving its intended accomplishments would be high.

This measure would complement the other primary and secondary planning objectives. Also, it would combine favorably with measures aimed at changing the timing and magnitude of releases from the increased pool, which would improve the quality of spawning and rearing habitat, increase attraction flows that cue in-migration, and improve water temperatures that cue out-migration. This measure would not conflict with other ecosystem restoration measures that were preliminarily retained, nor does it conflict with other known programs or projects on the upper Sacramento River.

- **Modify storage and release operations at Shasta Dam –** In addition to water temperature, flow conditions in the upper Sacramento River are important in addressing anadromous fish needs. Timing and magnitude of river flows are important to successful spawning and rearing of anadromous fish populations. This measure consists of enlarging Shasta Dam and modifying seasonal storage and releases to benefit anadromous fisheries in the Sacramento River by providing greater flexibility in achieving desirable river flows that would improve and expand suitable spawning and rearing habitat.

  Changes would be made to the timing and magnitude of releases performed to maintain target flows in spawning areas, and to improve the quality and quantity of aquatic habitat. Nearly all winter-run, and by far the majority of the spring-run and late-fall-run salmon in the Sacramento River, spawn in the reach upstream from the confluence with Battle and Cottonwood Creeks. It is within this reach of river that the measure would be most effective by reducing the frequency and magnitude of habitat dewatering. The quality of aquatic habitat could be further improved by cleaning spawning gravels. This measure could also include release changes during the flood season to permit “pulse flows" and other releases that could improve aquatic habitat conditions. Further, the measure could help provide additional control and dilution of acid mine drainage from Spring Creek.

Shasta Dam operates for multiple objectives, including water supply, flood control, water temperature, hydropower, and others. Modifying existing storage and release operations could adversely impact water supply reliability to agricultural and M&I uses or other beneficial uses of the water stored in the reservoir, which would be contrary to SLWRI goals and objectives. Therefore, this measure would need to include enlarging the storage space in Shasta Reservoir to mitigate potential adverse impacts to water supply reliability. This measure would not conflict with any ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects on the upper Sacramento River.

The estimated certainty of this measure in achieving its intended accomplishments would be moderate. The relationship between minimum river flows and increased survivability of salmon is not clear because many factors affect anadromous fish populations. Further, successful implementation would be highly dependent on the extent of dam modifications and reoperation that could be implemented while offsetting or minimizing adverse impacts to water supply or hydropower.

This measure was initially deleted from consideration because analyses indicated a decreased fisheries benefit with increasing Sacramento River flows compared to increasing the cold-water pool. However, this measure was subsequently retained as part of an adaptive management strategy for operation of the cold-water pool in Shasta Reservoir. Changes in operating the cold-water pool could include increasing minimum flows, timing releases out of Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional water in storage to meet temperature objectives.

Increase Water Supply Reliability

Various potential management measures were identified to address the primary objective of increasing water supply reliability for M&I, agricultural, and environmental purposes to help meet current and future water demands. Of 22 measures considered to help increase water supply reliability (see Table 2-3), four were retained for possible inclusion in concept plans. Rationale is discussed for retaining or deleting measures in this section.

Measures Considered

Following is a brief discussion of the measures considered, which are separated into eight categories: (1) increased surface water storage, (2) reservoir reoperation, (3) improved conjunctive water management, (4) coordinated operation and precipitation enhancement, (5) demand reduction, (6) improved water purchases and transfers, (7) improved Delta export and conveyance, and (8) improved surface water treatment. Also included are additional descriptions of the three measures retained for further consideration.

Increase Surface Water Storage Measures identified to increase surface water storages are described below.

- **Increase conservation storage space in Shasta Reservoir by raising Shasta Dam –** This measure consists of increasing the amount of available space for conservation storage in Shasta Reservoir through raising Shasta Dam. A range of potential dam raises has been considered in previous studies, including raises of more than 200 feet. A raise of 6.5 feet is included in the Preferred Program Alternative for the CALFED Programmatic ROD (2000a).

  This measure was retained for further development. Raising Shasta Dam would contribute directly to the primary planning objectives, and previous studies have indicated that raising the dam would be technically feasible. Raising Shasta Dam also could contribute to the secondary planning objectives. In addition, there is likely strong Federal and non-Federal interest in this measure.

Table 2-3. Management Measures Addressing the Primary Planning Objective of Increasing Water Supply Reliability

Management Measure	Potential to Address Planning Objective	Status/Rationale
Increase Surface Water Storage		
Increase conservation storage space in Shasta Reservoir by raising Shasta Dam	**Very High** – Raising dam directly contributes to increased water supply reliability.	**Retained** – Consistent with primary planning objectives and directly contributes to secondary planning objectives.
Construct new conservation storage reservoir(s) upstream from Shasta Reservoir	**Very Low** – Limited potential to effectively contribute to increased system water supply reliability or other planning objectives.	**Deleted** – Upstream storage sites capable of CVP system-wide benefits would be very costly, result in environmental impacts difficult to mitigate, and would be inconsistent with the CALFED Programmatic ROD.
Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam	**Low** – Several sites/projects, including Auburn Dam Project, have demonstrated an ability to contribute to system water supply reliability.	**Deleted** – Although potentially feasible sites/projects exist that could increase water supply reliability, considerable overriding environmental and socioeconomic issues restrict implementation at this time. Evaluated during the CALFED alternative development process.
Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Moderate to High** – Although not as effective as additional storage at Shasta, there is potential for offstream storage projects (NODOS) to contribute to increasing water supply reliability.	**Deleted** – Not as efficient as developing additional storage in Shasta Dam. NODOS being pursued as added increment to system through a separate feasibility-scope study initiated under Public Law 108-361. Evaluated during the CALFED alternative development process.
Construct new conservation surface water storage south of the Sacramento-San Joaquin Delta	**Moderate** – Potential for surface water storage projects (upper San Joaquin River) to contribute to increasing water supply reliability to CVP primarily in the San Joaquin Valley and Tulare Lake basin area.	**Deleted** – Not an effective alternative to additional storage at Shasta. Does not contribute to other planning objectives. Upper San Joaquin River being pursued as added increment to system through a separate feasibility-scope study initiated under Public Law 108-361. Evaluated during the CALFED alternative development process.
Increase total or seasonal conservation storage at other CVP facilities	**Moderate** – Would require several projects to contribute to water supply reliability (e.g., raise Folsom and Berryessa).	**Deleted** – Not an efficient alternative to increasing storage in Shasta Reservoir; considerably higher unit cost for increased water supply. Known efforts to increase space in other Northern California CVP (or SWP) reservoirs rejected by CALFED.
Dredge bottom of Shasta Reservoir	**Very Low** – Limited potential to effectively contribute to increases in system water supply reliability or any other planning objective.	**Deleted** – Extremely high cost for very small potential benefit and severe environmental impacts associated with disposal of dredged materials.
Reoperate Reservoir		
Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability	**Moderate to High** – Potential for increment of increased water supply reliability at Shasta Reservoir.	**Retained** – Although potential for increased water supply reliability is limited, added opportunities exist for increased flood control and other management elements.
Increase the conservation pool in Shasta Reservoir by encroaching on dam freeboard	**Very Low** – Very small space increase possible.	**Deleted** – Very limited potential to encroach on existing freeboard above full pool, which is only 9.5 feet. Major modifications would be required to the dam and appurtenances to allow operational encroachments on the design freeboard of the dam, only to gain a small potential increase in reservoir storage.
Increase conservation storage space in Shasta Reservoir by reallocating space from flood control	**Low** – Space reallocated to water supply could contribute to increased water supply reliability.	**Deleted** – Very low potential for implementation due to considerable adverse impacts on flood control.
Improve Conjunctive Water Management		
Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam	**Moderate** – Potential to enhance water supplies for system deliveries when combined with new storage and reoperation of Shasta Dam and Reservoir.	**Deleted** – Implementing additional surface water storage project increment for Shasta would not be as efficient as new storage in Shasta Reservoir. Potential for shared storage in NODOS project is being considered in separate feasibility study initiated under Public Law 108-7. Evaluated during the CALFED alternative development process.
Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam	**Moderate to High** – Considerable potential to enhance water supplies for system deliveries when combined with new storage and reoperation of Shasta Dam and Reservoir.	**Deleted** –This measure was initially retained for inclusion in concept plans, then eliminated in the comprehensive plans phase due to subsequent operations modeling indicating trade-offs between conjunctive use water supply benefits and critical gains in fisheries accomplishments.
Develop additional conservation groundwater storage south of the Sacramento-San Joaquin Delta	**Moderate** – Potential to enhance water supplies for system deliveries when combined with new storage and reoperation of Shasta Dam and Reservoir.	**Deleted** – Not as effective as storage north of the Delta and would not contribute to other study objectives. Evaluated during the CALFED alternative development process.
Coordinate Operation and Precipitation Enhancement		
Improve Delta export and conveyance capability through coordinated CVP and SWP operations	**Moderate** – Potential to enhance water supplies for system deliveries when combined with new storage and reoperation of Shasta Dam and Reservoir.	**Deleted** – Joint point of diversion is being actively pursued in other programs. A likely without-project condition.
Implement additional precipitation enhancement	**Low** – Low potential to provide improvements to drought period water supply reliability.	**Deleted** – Not an effective alternative to new storage. Very limited potential to benefit drought period water supply reliability. Being actively pursued under without-project condition.

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Table 2-3. Management Measures Addressing the Primary Planning Objective of Increasing Water Supply Reliability (contd.)

Management Measure	Potential to Address Planning Objective	Status/Rationale
Reduce Demand		
Implement water use efficiency methods	**Moderate** – Potential to benefit overall State water supply issues.	**Retained** – Although water use efficiency does not add to increased supplies, conservation is being actively pursued through other programs. Conservation needs to be considered as an element of any plan considered in addressing California's future water picture.
Retire agricultural lands	**Moderate** – Would reduce water demand rather than increase ability to meet projected future demands.	**Deleted** – Limited potential to help meet future water demands in the Central Valley. Agricultural lands of marginal value are often already fallowed during drought periods. High degree of uncertainty regarding the ability to acquire and retire sufficient higher productivity lands. Land retirement test programs being performed by Reclamation under other programs. On a large scale, could have considerable negative impacts on agricultural industry.
Improve Water Transfers and Purchases		
Transfer water between users	**Very Low** – Does not generate an increase in water supply reliability**.**	**Deleted** – Not an alternative to new water sources or reliable substitute for new storage at Shasta Reservoir. Will likely be accomplished with or without additional efforts to develop new sources. Evaluated during the CALFED alternative development process.
Expand Delta Export and Conveyance Facilities		
Expand Banks Pumping Plant	**Moderate** – Potential to help increase water supply reliability south of the Delta.	**Deleted** – Not an alternative to new storage north of the Delta. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Construct DMC/CA intertie	**Moderate** – Potential to help increase water supply reliability south of the Delta.	**Deleted** – Not an alternative to new storage north of the Delta. Does not address planning objectives or constraints/principles/criteria. Will likely be accomplished with or without additional efforts to develop new sources.
Improve Surface Water Treatment		
Implement treatment/supply of agricultural drainage water	**Very Low** – Very low potential to improve water supply reliability for agricultural uses.	**Deleted** – Not a viable alternative to new water storage. High unit water cost. Evaluated as part of the CALFED Water Quality Program.
Construct desalination facility	**Low** – Although growing new source for urban water supplies in State, low potential to address SLWRI planning objectives.	**Deleted** – Low potential to address the primary planning objective of agricultural water supply reliability. Most efficient when used as a base water supply; highly inefficient in providing drought period water supplies. Very high unit water cost. Evaluated as part of the CALFED Water Use Efficiency Program.

Key:
CALFED = CALFED Bay-Delta Program
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
DMC/CA = Delta-Mendota Canal/California Aqueduct
NODOS = North-of-the-Delta Offstream Storage
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
ROD = Record of Decision
SLWRI = Shasta Lake Water Resources Investigation
State = State of California
SWP = State Water Project

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- **Construct new conservation storage reservoir(s) upstream from Shasta Reservoir –** This measure consists of constructing dams and reservoirs at one or more locations upstream from Shasta Lake, primarily for increased water conservation storage and operational flexibility. Numerous reservoir storage projects have been considered and many constructed in the watershed upstream from Shasta Lake. Three of the most promising remaining sites include Allen Camp Reservoir (180,000 acre-feet on the Pit River in Modoc County), Kosk Reservoir (800,000 acre-feet on the Pit River in Shasta County), and Squaw Valley Reservoir (400,000 acre-feet on Squaw Valley Creek in Shasta County). These three potential project sites were deleted from further consideration because they (1) would only be capable of marginally improving water supply reliability to the CVP, (2) would not be consistent with screening criteria established in the CALFED Integrated Storage Investigations (e.g., would not provide a minimum storage capacity of at least 200,000 acre-feet), (3) would likely not be supported in the local area because the water would need to be developed for CVP system reliability (not retained for local use), or (4) would result in a relatively high unit water cost to implement. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

  In addition to the above three potential projects, an additional offstream storage site at Goose Valley near Burney was suggested to the SLWRI Project Delivery Team during a stakeholder meeting in Redding. A cursory evaluation indicated, however, that at a potential full pool storage of about 230,000 acre-feet, and with a generous estimate of available river flows available for diversion from the Pit River to the site, likely costs to develop the project would exceed water supply benefits by at least 2 to 1. Although larger sizes of a project at the Goose Valley site are physically feasible, there is little potential for water to fill the facility. Accordingly, this site was not considered further and this measure was deleted from further consideration in the SLWRI.

- **Construct new conservation storage on tributaries to the Sacramento River downstream from Shasta Dam –** Numerous onstream surface water storage projects along tributaries to the Sacramento River downstream from Shasta Dam were evaluated during the CALFED alternatives development process and other past studies. Several projects were identified as having potential to contribute considerably to increasing water supply reliability, including the Cottonwood Creek Project (1.6 MAF on Cottonwood Creek north of Red Bluff), the Auburn Dam Project (up to about 2.3 MAF on the

Middle Fork American River near Sacramento), and the Marysville Lake Project (920,000 acre-feet on the Yuba River near Marysville). Although each of these potential projects could considerably contribute to increasing the water supply reliability of the CVP and SWP systems, they have been rejected by State and local interests as potential candidates for new water sources.

This measure was deleted from further consideration in the SLWRI as the potential onstream surface storage projects would not efficiently contribute to the primary planning objective of increasing water supply reliability (e.g., would result in a relatively high unit water cost to implement compared to enlarging Shasta Reservoir and other surface storage projects identified in the CALFED Preferred Program Alternative) or because they would have significant overriding environmental issues and opposition. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

- **Construct new conservation offstream surface storage near the Sacramento River downstream from Shasta Dam –** Various offstream reservoir storage projects have been evaluated in previous studies. All but one of the offstream reservoir storage projects were eliminated from further consideration in the CALFED Programmatic ROD, primarily because of project cost considerations, potential environmental impacts, and lands and relocation issues. The one project retained for further consideration in the CALFED Programmatic ROD is Sites Reservoir, with a storage capacity of up to 1.8 MAF. DWR is the lead agency studying Sites Reservoir and alternatives under the North-of-the-Delta Offstream Storage (NODOS) Project. Sites Reservoir would be filled primarily by water diverted from the Sacramento River and tributaries during periods of excess flows through the Tehama-Colusa Canal, Glenn-Colusa Irrigation District Canal, and/or a new pipeline near Maxwell. Another potential source of water for filling the reservoir is moving (predelivery) Tehama-Colusa Canal Authority and Glenn-Colusa Irrigation District water from Shasta Reservoir during the spring and storing it at Sites Reservoir for delivery during the irrigation season. Reclamation received Federal feasibility study authority for NODOS under Section 215 of PL 108-7 in September 2003. NODOS has the potential to increase the water supply reliability of Sacramento Valley users, the CVP, and SWP; improve Delta water quality; contribute to ecosystem restoration; and provide water to support the Environmental Water Account.

Since DWR and Reclamation are studying Sites Reservoir under the NODOS Project as an independent project from the SLWRI, this measure was deleted from further consideration under the SLWRI. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

- **Construct new conservation surface water storage south of the Sacramento-San Joaquin Delta –** A relatively large portion of the CVP's future water needs is located in service areas in the San Joaquin River basin, south of the Delta. In addition, large demands will continue to be made, primarily on the SWP, to provide water for M&I purposes farther south via the California Aqueduct (CA) and for increased water supply reliability to the South Bay areas. A portion of these demands could be provided by onstream and/or offstream surface water storage within the San Joaquin River basin. Numerous surface water storage sites have been identified in the past along the east and west sides of the San Joaquin Valley and in areas to the west of the Delta near Stockton.

  Potential onstream storage sites are exclusively located on the east side of the valley due to the lack of substantial annual runoff from the Coast Range. Several potential onstream storage sites could include enlarging Pardee Reservoir on the Mokelumne River, enlarging and modifying Farmington Dam on Littlejohns Creek, and additional storage on the upper San Joaquin River. Numerous potential offstream storage sites also have been considered in the San Joaquin Valley. Several potential sites have been identified on the east side of the valley and would receive diverted flows from nearby rivers, but most sites are on the west side of the valley and designed to receive pumped water primarily from the CA during periods of excess flows. Potential sites would include Los Vaqueros enlargement, Ingram Canyon Reservoir, Quinto Creek Reservoir, and Panoche Reservoir.

  This measure was eliminated from further consideration because, except for those included in the CALFED Preferred Program Alternative, all of the potential onstream or offstream storage projects south of the Delta would not (1) contribute to the primary objective of increasing anadromous fish survival in the upper Sacramento River, or (2) be as efficient or effective at increasing water supply reliability as additional storage in an enlarged Shasta Reservoir. In addition, feasibility-scope investigations for both Los Vaqueros Reservoir and upper San Joaquin River storage were authorized in Section 215 of Public Law 108-7. Both studies are addressing specific planning objectives that are unique to their geographic areas, but differ from those of the SLWRI. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

- **Increase total or seasonal conservation storage at other CVP facilities –** This measure primarily consists of providing additional conservation storage space in other major CVP (and/or SWP) reservoirs in the Sacramento River watershed through enlarging existing dams and reservoirs. Besides Shasta Dam and Lake, projects primarily would include additional storage in facilities such as Lake Berryessa on Putah Creek, Folsom Lake on the American River, Trinity Lake on the Trinity River, and Lake Oroville on the Feather River. However, these potential projects were deleted from further consideration because they (1) would only be capable of marginally improving water supply reliability, (2) would not be consistent with screening criteria established in the CALFED Integrated Storage Investigations (e.g., would not provide a minimum storage capacity of at least 200,000 acre-feet), (3) would result in a relatively high unit water cost to implement, or (4) or because they would have significant overriding environmental issues.

  This measure was deleted from further consideration in the SLWRI primarily because potential enlargement of other existing CVP (and/or SWP) facilities in the Sacramento River watershed would not efficiently contribute to the primary planning objective of increasing water supply reliability (e.g., would result in a relatively high unit water cost to implement compared to enlarging Shasta Reservoir) or because they would have significant overriding environmental issues. It is believed that, of the existing reservoirs in the CVP/SWP systems, increasing water supply reliability through modifying Shasta Dam and Lake would be the most cost-effective. Further, efforts to increase storage space in other northern California CVP (or SWP) reservoirs were rejected by CALFED and local interest groups. . Additionally, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

- **Dredge bottom of Shasta Reservoir –** This measure consists of increasing the total storage space in Shasta Reservoir by excavating either deposited or native materials below full pool elevation. In general, this measure is not practical for large impoundments due to cost; however, it is included here for completeness and because it was a specific request in the environmental scoping process. For comparison purposes, an estimate was made that considered removing 100,000 acre-feet of dredged material from Shasta Reservoir. This volume in Shasta Reservoir would result in approximately 22,000 acre-feet per year of additional dry and critical year water supplies for CVP deliveries. An increased volume of 100,000 acre-feet is about 160 million cubic yards, or the equivalent volume of the area of a football field over 14 miles high. Excavation costs vary widely depending on the type of material and location of excavation. Soil that is movable by scraper machines can be excavated and dumped locally for about $3 per yard while dredged soil costs much more, over $10 per yard, and rock excavates are about $10 per yard. Assuming that Shasta Reservoir is drawn down and half of the volume is removed by scraper and half by excavation, and then assuming transport and disposal of the material locally at an additional cost of approximately $3 yard, this measure would have a total cost of about $1.5 billion. This cost does not include any real estate costs or expenditures to mitigate for drawing down Shasta Lake or for the disposal of the materials. In addition, the soil and rock could not be sold because no need exists for this quantity of fill, and local fill sources are usually available. The resulting equivalent cost of increasing water supply reliability would be nearly $5,000 per acre-foot. This unit cost is multiple times greater than that of other sources.

This measure was deleted from further consideration primarily due to cost. There is also potential for severe environmental impacts associated with disposal of materials.

Reoperate Reservoir The three measures described below involve increasing the conservation storage space by altering the operations of Shasta Dam and Reservoir.

- **Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operations for water supply reliability –** This measure consists of changing the flood control operations of Shasta Dam and Reservoir (without reducing the maximum flood pool) with a goal of increasing water supply reliability. This measure would focus on revising the operation rules for flood control such that the facility could potentially be managed more efficiently for flood control, thereby freeing some seasonal storage space for water supply. A primary constraint would be to ensure no adverse impacts to the existing level of flood protection provided by the Shasta Dam project. It is believed that some degree of operational efficiency could be gained through a critical assessment of reservoir operations using more current analytical and weather forecasting tools.

  This measure was retained for further detailed consideration for possible inclusion in concept plans, although the potential for increased water supply reliability through reoperation efficiencies for flood control is believed to be limited.

- **Increase conservation pool in Shasta Reservoir by encroaching on dam freeboard –** This measure consists of increasing the conservation storage space in Shasta Reservoir by raising the full pool elevation without raising Shasta Dam. The current full pool elevation at Shasta Dam is 1,067 feet above mean sea level (elevation 1,067) and the top-of-dam elevation is approximately elevation 1,076.5. Accordingly, the design freeboard above maximum water surface elevation is 9.5 feet. It is estimated that major modifications would be required to the dam and appurtenances to allow operational encroachments on the design freeboard of the dam, only to gain a small potential increase in reservoir storage.

  This measure was deleted from further consideration primarily because it would have low potential to effectively address the planning objective of increased water supply reliability.

- **Increase the conservation storage space in Shasta Reservoir by reallocating space from flood control –** This measure consists of decreasing the maximum seasonal flood control storage space in Shasta Reservoir and dedicating that space to water supply reliability in the CVP. It also includes constructing flood protection features along the Sacramento River to mitigate for potential induced flood damages. The maximum seasonal flood control storage space in Shasta is 1.3 MAF from December 1 through March 20, depending on accumulated seasonal inflow volumes. Reducing seasonal flood control storage space would reduce the ability of the reservoir to control peak flood flow releases. This would result in an increase in the frequency of flooding and flood damages along the Sacramento River downstream from Shasta Dam.

  This measure was deleted from further consideration in the SLWRI primarily because of its likely adverse impacts on flood controls.

Improve Conjunctive Water Management The following three measures were identified to improve conjunctive water management.

- **Develop conservation offstream surface storage near the Sacramento River downstream from Shasta Dam –** This measure consists of developing surface water transfer storage capabilities near the Sacramento River downstream from Shasta Dam to use in conjunction with storage in Shasta Reservoir. This storage would be an extension of storage space in Shasta Reservoir. Water temporarily stored or “parked” in the transfer storage facility would be delivered to local CVP contractors in substitution for their current diversions via either the Anderson-Cottonwood Irrigation District facilities or Tehama-Colusa Canal water users facilities. Water not diverted from the water users would remain in the Sacramento River to benefit anadromous fish, for delivery to downstream water users, and/or for Delta water quality. One possibility identified would be to consider some of the space in the Sites Reservoir project, or NODOS, which was previously described as new conservation surface storage for Shasta. This possibility is being considered in studies by DWR.

This measure was deleted from further consideration in the SLWRI as the development of a separate surface water storage project or space in the Sites Project expressly as part of the SLWRI is believed to be inconsistent with the planning objectives and constraints for the SLWRI. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required. It continues to be considered, however, as part of the NODOS project.

- **Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam –** This measure consists of developing groundwater storage near the Sacramento River. Similar to the surface storage measure described above, releases from Shasta Dam would be diverted from the Sacramento River and used to recharge local groundwater rather than be stored in a surface water facility. During drought periods, stored groundwater would be pumped for local uses. This pumped water would be substituted for surface water that would have otherwise been diverted from the Sacramento River during the irrigation season. Several options have been identified. One option, active recharge, would be similar to surface water conjunctive use storage except diverted water would be stored in groundwater basins adjacent to the Sacramento River. However for regions with high natural recharge, such as the northern Sacramento Valley, active recharge is not as efficient as in-lieu recharge due to the additional capital and operations and maintenance (O&M) costs associated with active recharge facilities. Consequently, in-lieu recharge was retained for consideration. Another option would be to work with existing water contractors in the Sacramento River valley to exchange surface water for in-lieu pumped groundwater, depending on the water year.

  The in-lieu option of this measure was retained primarily because it would have potential to increase water supply reliability and would be consistent with the identified plan formulation constraints and criteria. Also, it would be consistent with CALFED goals for the water storage component of the 2000 CALFED Programmatic ROD and would not conflict with other planning objectives.

- **Develop additional conservation groundwater storage south of the Sacramento-San Joaquin Delta –** This measure consists of either developing new groundwater recharge projects south of the Delta or contributing to existing recharge projects. It would include diverting flows during periods of excess from the San Joaquin River, Delta-Mendota Canal (DMC), or CA and helping recharge depleted groundwater basins. It is believed that this measure would have limited potential to allow storage from modifying Shasta to be temporally stored south of the Delta for later use during critical dry periods. Conjunctively using water in the DMC or CA has been pursued in other CALFED programs. These conjunctive use scenarios would not be considerably influenced by added system storage north of the Delta.

  This measure was deleted from further consideration in the SLWRI primarily because it would not be as effective or efficient as increased storage space in Shasta Reservoir and would not effectively address the primary planning objective of increasing anadromous fish survival in the upper Sacramento River. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

Coordinate Operation and Precipitation Enhancement The two measures discussed below involve coordinating operations and precipitation enhancement.

- **Improve Delta export and conveyance capability through coordinated CVP and SWP operations –** This measure primarily consists of improving Delta export and conveyance capability through a more effective coordinated management of surplus flows in the Delta. A specific application of the measure would be the joint point of diversion. Joint point of diversion operations would allow Federal and State water managers to use excess or available capacity in their respective south Delta diversion facilities at the Jones and Banks pumping plants. Currently, little excess capacity exists in the Federal pumps at Jones, but some additional capacity is available in the SWP pumps at Banks. The potential added benefit to CVP through joint point of diversion operations during average and critical years would be about 61,000 and 32,000 acre-feet, respectively. This measure is being actively pursued by Reclamation and DWR and it is highly likely that some form of the joint point of diversion will be implemented in the future.

  This measure was deleted from further consideration in the SLWRI because it would not effectively address the primary planning objectives, and is likely to be implemented, in some form, independent of the SLWRI.

- **Implement additional precipitation enhancement –** Precipitation enhancement is a process by which clouds are stimulated to produce more rainfall or snowfall than they would naturally. This process is accomplished by seeding a cloud with a substance such as silver iodide, an ice-like structure, that encourages water to form ice particles heavy enough to fall out as rain or snow. Precipitation enhancement has been practiced continuously in California since the 1950s for water supply and hydroelectric power purposes. It is estimated that about a 2 to 15 percent increase in annual precipitation or runoff can be achieved by this process. Indications are that precipitation enhancement is highly cost-effective in increased average annual rainfall. It has been determined that this technology likely does not decrease downwind precipitation. However, environmental concerns exist about weather modification.

  It is important to understand that precipitation enhancement is not a short-term remedy for droughts because supply increases can only be achieved during years when it would otherwise rain or snow naturally, meaning in above-average precipitation years. Accordingly, precipitation enhancement is not an alternative to new system storage, which focuses on conserving water in wetter years for use in drier years. In addition, this technology is being pursued under the without-project condition.

  This measure was deleted from further consideration in the SLWRI primarily because it would not address the planning objectives and is not an alternative to new storage in Shasta Reservoir.

Reduce Demand Measures identified to reduce demand and thus increase water supply reliability are described below.

- **Implement water use efficiency methods –** Water use efficiency methods can help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies remain relatively static, effective use of supplies can reduce potential critical impacts to urban and agricultural resources resulting from water shortages.

  Reclamation is an implementing agency for the CALFED Water Use Efficiency program (CALFED 2000a). The Water Use Efficiency Program was developed to support efficient use of water supplies developed by CALFED. The program is comprised of a combination of technical assistance, grants and loans, and directed studies in program areas including: agricultural water conservation, urban water conservation, water recycling, and desalination. The program coordinates with, builds on, and supplements the work of the Agricultural Water Management Council and the California Urban Water Conservation Council. Supporting information for the program is contained in a *2006 Water Use Efficiency Comprehensive Evaluation* for the CALFED Water Use Efficiency Element (CALFED 2006) and the *California Water Plan 2009 Update* (DWR 2009).

The 2009 *California Water Plan Update* (DWR) also identified a host of agricultural and urban water conservation measures. It is important to note that water "saved" by conservation practices is often water that, without conservation, would return to the hydrologic system and become a supply for other users. Accordingly, conservation does not simply mean reducing consumptive uses for crops in agricultural areas or for dwelling units in urban areas. Truly effective conservation applies when it consists of reducing irrecoverable water, or reducing water use that otherwise would be lost to the hydrologic system. For agricultural uses, examples of irrecoverable water would be (1) water used to leach salts from the soil and subsequently lost to the system through collection and evaporation (2) water lost to excessive evaporation or transpiration, or (3) channel evaporation losses. For urban uses, examples of genuine water conservation would be reducing (1) residential landscape water lost to evaporation or transpiration; (2) commercial, industrial, and institutional losses that are not recoverable; and (3) water distribution system losses or leakage in areas where water would not be recoverable.

The 2006 CALFED document indicated that the potential for recovering currently irrecoverable agricultural losses in the Sacramento and San Joaquin River Basins could be about 142,000 acre-feet on an average annual basis - with resulting unit costs of about $200 per acre-foot. Larger recoveries of currently irrecoverable agricultural losses are technically feasible; however, the costs to achieve these amounts increase considerably. The report also identified various urban water use efficiency programs with the potential of reducing average annual urban water use up to about 1.1 MAF per year by 2030 through a series of best management practices. These practices ranged from potentially cost-efficient regional opportunities likely to be implemented in the future to those requiring grant funding and cost-sharing before they could be implemented. It is estimated that implementation costs (using approaches somewhat similar to those being considered for the surface water storage projects) would exceed about $300 per acre-foot for these reductions. Note that either recovery of irrecoverable agricultural losses, or reductions in urban water use during drought years would be considerably less than in average years. Accordingly, the unit cost for achieving drought period reductions in water use would be considerably greater than the average unit cost above.

Many actions planned under the CALFED Water Use Efficiency program will be accomplished with or without implementation of other projects to address water supply reliability. “Projection Level One” includes continued implementation of best management practices for urban and agricultural conservation equivalent to those observed during the first 13 years of CALFED. The CALFED Common Assumptions for Water Storage Projects estimated that Level One has a potential to reduce future agricultural losses by about 49,000 acre-feet per year and urban demands in the State by about 1.2 MAF per year. Additional water conservation measures will likely play a major role in California’s future water picture. The California Water Plan as well as numerous State and Federal agencies endorse and actively engage in water use efficiency actions. Water use efficiency will constitute a significant element in helping to reduce demands to help offset future shortages in water supplies.

This measure was retained as a potential project element to be considered to the extent possible in the implementation of a potential plan of action for the SLWRI.

- **Retire agricultural lands –** Recent studies indicate that by retiring about 150,000 acres from irrigated croplands in the San Joaquin Valley, the demand for irrigation water could be reduced by about 260,000 acre-feet per year under average conditions. It is estimated that in dry and critical years, potential savings through this measure could be much reduced from the average annual value because it is during these water-short years that marginal lands are normally allowed to go fallow. Some estimates have placed the drought period demand reduction at between 100,000 and 150,000 acre-feet per year. The estimated construction cost to acquire land rights to permanently retire lands from irrigated agriculture uses amounts to about $500 million, resulting in an equivalent dry-period unit water cost of about $300 per acre-foot. Although the equivalent unit cost of water for this measure may be found competitive with other potential water sources, this measure likely has limited ability to actually address meeting future water demands in the Central Valley.

  The ability of this measure to meet future water demands in the Central Valley is limited. First, as mentioned, marginal lands are already often allowed to fallow during drought periods. Further, there would be a high degree of uncertainty regarding the institutional ability to acquire sufficient additional land rights necessary to preclude future irrigated agriculture on lands identified for inclusion in a project/program. This especially would be the case if efforts were made to acquire and retire higher productivity lands that may actually lead to water savings during drought periods. Further, there is believed to be a limited ability to successfully apply this measure to lands in the Central Valley at costs similar to those above for less productive lands.

This measure was deleted from further consideration as this measure likely has limited ability to help meet future water demands in the Central Valley and would not address the primary objective of increasing anadromous fish survival in the upper Sacramento River. Furthermore, at a large scale, this measure could have considerable negative impacts on agricultural production and related industries.

Improve Water Transfers and Purchases To improve water transfers and purchases, the following measure was identified.

- **Transfer water between users –** Water purchases and transfers do not generate new water for the CVP. They simply consist of transferring water between a seller willing to forgo a water use for a time and a willing buyer within the Central Valley. The availability and price of a supply for purchase and used for transfer depends on several factors such as year type, other available supplies, storage capabilities, and transmission capacity. Temporary and long-term (greater than 1 year, as defined by DWR) transfers between water districts have increased from about 80,000 acre-feet in 1985 to over 1.2 MAF in 2001. This trend is expected to continue as the demand for available supplies continues. Only about 20 percent of the transfers are based on agreements greater than 1 year. Most depend on the water spot market. Both Reclamation and DWR also have active water transfer programs and a significant number of water transfers will continue to occur in the future under without-project conditions as available supplies become scarce. Further, the future of the Environmental Water Account depends on the ability to acquire and transfer water through the Delta to mitigate impacts of south Delta pumping curtailment to benefit at-risk fish. Because of these and other projects and actions, and ongoing infrastructure limitations on conveying water from north of the Delta south, it is believed that as water supply demands continue to grow and exceed developed supplies, especially during dry years, and as market conditions change, the cost of water is expected to increase considerably. It is likely that the most feasible and reliable water transfers will be implemented under without-project conditions. Any remaining opportunities for transfers likely would be small, include high uncertainties, be difficult to implement, and be more costly. In addition, water transfers are unlikely to contribute to improving water quality (particularly during dry periods) or provide a less-costly Environmental Water Account replacement supply (transfers are a water acquisition tool already used by the Environmental Water Account).

This measure was deleted from further consideration primarily because it would not be a long-term reliable substitute for new storage in Shasta Reservoir. Furthermore, this measure was considered as a measure under CALFED. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

Expand Delta Export and Conveyance Facilities – The two measures in this category would divert surplus water when safe for fish, then bank, store, transfer, and release the surplus water as needed to protect fish and to compensate water users. This could be accomplished by increasing the capacity of conveyance facilities of the CVP and SWP at several locations, as follows:

- **Expand Banks Pumping Plant –** The current allowable pumping capacity at the SWP Banks Pumping Plant is 6,680 cfs. Efforts are underway by Reclamation and DWR to construct fish protection features under the South Delta Improvements Program to allow increasing the allowable pumping capacity to 8,500 cfs during certain seasonal periods. The maximum installed pumping capacity at Banks is about 10,300 cfs. This measure primarily includes implementing additional physical features and operational improvements aimed at benefiting the overall water quality of the Delta to further increase the allowable pumping capacity at Banks from 8,500 cfs to 10,300 cfs during certain seasonal periods, and splitting the increased pumping capacity equally between the CVP and SWP. This increased capacity would allow more water that otherwise would flow to the Pacific Ocean to be conveyed south of the Delta. It is estimated that the average annual increase in supplies south of the Delta allocated to the CVP could amount to over 100,000 acre-feet. The estimated unit cost for the increase in water supply reliability would be highly efficient when compared with other potential sources of new water supplies.

  This measure was deleted from further consideration in the SLWRI because this measure would not contribute to the SLWRI planning objectives or identified plan formulation constraints, principles, and criteria; it was not viewed as a potential alternative to new storage in Shasta Reservoir.

- **Construct Delta Mendota Canal/California Aqueduct (DMC/CA) intertie –** The pumping capacity of the CVP Jones Pumping Plant into the DMC in the south Delta is 4,600 cfs. However, because of land subsidence in the southern reaches of the DMC, the effective capacity is limited to 4,200 cfs. Studies have considered modifying the subsided reach of canal and constructing a new canal parallel to the existing DMC. However, it appears that a more cost-effective measure would be to connect the DMC to the CA. In some locations, the two canals are about 400 feet apart horizontally and 50 feet apart vertically. A potential intertie would consist of constructing pumps and a 400 cfs capacity conveyance canal between the two facilities several miles south of the Jones Pumping Plant. It is estimated that this measure would result in an average annual increase in supplies south of the Delta of about 55,000 acre-feet. It is believed that the unit cost for the increase in water supply reliability for this measure would be comparable to other potential sources of new water supplies.

This measure was deleted from further consideration in the SLWRI because this measure would not contribute to the planning objectives of the SLWRI or identified plan formulation constraints, principles, and criteria; it was not viewed as a potential alternative to new storage in Shasta Reservoir.

Improve Source Water Treatment The following two measures were identified to improve source water treatment.

- **Implement treatment/supply of agricultural drainage water –** The treatment of agricultural drainage water was considered as part of the CALFED Water Quality Program. This measure consists of collecting agricultural drainage from farms along the Sacramento and San Joaquin Rivers and treating the drainage water for reuse. Major elements of this measure likely include an agricultural drainage collection system, pretreatment of drainage water, desalination facilities, ancillary facilities associated with desalination and brine disposal, and conveyance of treated water to end users. In addition, removing total organic carbon and pesticides plus supplementary disinfection may also be required before municipal agencies would consider using the treated agricultural runoff as a potable supply. Similar drainage treatment estimates range from $459 to $641 per acre-foot. It should be noted, however, that these costs do not include the cost of collecting and transporting the saline water to the desalter or the costs of disposing of the concentrate (Buena Vista Water Storage District et al. 2004). While this measure may have potential to provide some water supply reliability to urban users, it is far too costly for agricultural users.

  This measure was deleted from further consideration as it would be costly to initially implement and operate, problems would exist relating to brine disposal, and it would likely be unacceptable to stakeholders and the public. Furthermore, the treatment of agricultural drainage water was considered as a measure under CALFED as part of the Water Quality Program. Since this EIS tiers to the CALFED PEIS/R, it relies on the analysis and screening evaluations performed for the CALFED PEIS/R. Revisiting alternatives that were considered alongside CALFED's Preferred Program Alternative is not required.

- **Construct desalination facility –** This measure was considered as part of the CALFED Water Use Efficiency Program (CALFED 2006). This measure consists of constructing seawater or brackish surface or groundwater desalination plants to supplement existing water supplies and help offset future demands. There are 23 desalination facilities with a total capacity of about 80,000 acre-feet per year currently operating in California to provide water for municipal purposes. It is estimated that by 2030, a total of 49 desalination facilities with a cumulative capacity of nearly 600,000 acre-feet per year will be in operation in California. Primary elements of any of the facilities include a water intake, pretreatment, desalination, brine disposal, and ancillary facilities for the desalination treatment plant. In addition, a conveyance system is needed to transport the desalinated water to the customer or to the water agency distribution systems. Although technological advances have substantially decreased treatment costs, desalination remains costly compared with most other water sources. Even with continual improvement in membrane technology, energy costs can account for as much as one-half the total cost of desalination.

  Desalination is most efficient when used as a base supply because the plants can be better and more cost-effectively maintained if continuously operated, rather than if they are only operated during drought periods. Alternately, if desalination were operated as a base supply in all years, reserving contract water for use during drought periods, less expensive average and wet-year contract water would be forgone in most years. Consequently, desalination by itself would be a highly inefficient option for agencies that rely on multiple water sources or only intend to use desalination as a drought or emergency supply.

  Depending greatly on the quality of the source water and the cost of power, desalination today can range from about $700 to several thousand dollars per acre-foot. As mentioned, desalination is energy intensive and, with rising power costs, it is expected to continue to be relatively expensive. Even if the unit cost for a base supply plant were measurably reduced, desalination by itself would likely not be superior to other potential water sources to address the primary planning objective of agricultural water supply reliability in the SLWRI.

  Accordingly, this measure was deleted from further consideration primarily because it has low potential to address the planning objective of increasing agricultural water supply reliability. Desalination would not be an efficient alternative to new storage in Shasta Reservoir because it would be highly inefficient in providing drought period water supplies and its unit costs would be far greater than new supplies from Shasta or other sources.

Measures Retained for Further Consideration

Four of the above management measures to increase water supply reliability were retained for further consideration and possible inclusion in concept plans. Of these four, three were carried forward for inclusion in comprehensive plans. Their major components and accomplishments are described below.

- **Increase conservation storage space in Shasta Reservoir by raising Shasta Dam –** This measure consists of structural raises of Shasta Dam ranging from about 6.5 feet to approximately 200 feet. Chapter 3 includes descriptions of features, accomplishments, major impacts, and costs for various dam raises within this range. Also included in the chapter is a comparison of various dam raise options.

- **Increase effective conservation storage space in Shasta Reservoir by increasing efficiency of reservoir operation for water supply reliability –** This measure consists of modifying the operation of Shasta Dam to improve water supply reliability. It can also assist in improving flood control. Potential methods to improve water supply reliability include modifying rainflood parameters – those which address space for flows from winter rainfall – in the operation rules for Shasta Reservoir and modifying the Shasta Dam release schedule. The goal of the operation changes would be to minimize the required evacuation of the reservoir during the period from about late November through March, and to possibly allow the reservoir to be filled more rapidly in the spring. As mentioned, a primary criterion would be to prevent adversely affecting existing flood protection provided by Shasta Dam and possibly improve it. These possible reoperation opportunities are described in the reference report *Assessment of Potential of Shasta Dam Reoperation for Flood Control and Water Supply Improvement* (Reclamation 2004b).

  Although this measure was retained for inclusion in concept plans, its specific features and their influence on water supply reliability and flood damage reduction would not be developed until detailed operations modeling could be accomplished in further investigations as part of comprehensive alternative plan formulation in the SLWRI.

- **Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam –** This in-lieu conjunctive water management measure primarily consists of using the incremental increase in stored water in Shasta Reservoir to support a shift in the timing of water diversion from the Sacramento River to help increase water supply reliability to other CVP and possibly SWP water users in dry periods. Under this measure, for agricultural interests willing to participate in an in lieu program, during average and wetter years, more surface water from an increased storage space in Shasta Reservoir would be diverted from the Sacramento River and used in-lieu of groundwater pumping. Accordingly, during drought years, less surface water would be delivered to agricultural users, who would depend more on groundwater supplies, allowing more of the normally diverted surface water to be delivered to other users. The in lieu conjunctive water management program would need to include incentives to agricultural users to warrant their participation.

Although this plan was initially retained due to significant water supply benefits, it was eliminated from further development during the comprehensive plan phase. Subsequent operations modeling indicated tradeoffs between conjunctive use water supply benefits and critical gains in fisheries accomplishments. The resulting reduction in benefits to fisheries operations in dry and critical years was deemed unacceptable in terms of meeting primary project objectives.

- **Implement water use efficiency methods –** Water use efficiency methods can help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow, and available supplies remain relatively static, more effective use of supplies can reduce potential critical impacts to urban and agricultural resources resulting from water shortages. The California Water Plan Updates 2005 and 2009 (DWR 2005, DWR 2009) identified a host of urban and agricultural water use efficiency measures. The 2009 plan indicates that water use efficiency measures, although costly and difficult to implement, will play a major role in California's water future. Water use efficiency will constitute a significant element in helping to reduce demands to help offset future shortages in water supplies. Accordingly, water use efficiency was retained for consideration as a potential project element for any plan to be considered for the SLWRI.

Measures to Address Secondary Planning Objectives

Various management measures were identified to address the five secondary planning objectives. For each secondary planning objective, measures were identified and separated into categories. In the following sections, the rationale is discussed for retaining or deleting each measure.

Conserve, Restore, and Enhance Ecosystem Resources

Identifying potential ecosystem restoration opportunities included management measures to address the secondary planning objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam. Of the 19 management measures identified to address the secondary planning objective of ecosystem restoration, three were retained for possible inclusion in concept plans (see Table 2-4). As discussed below, many of the management measures considered to address increasing anadromous fish survival are encompassed under the ERP, which was included as part of the CALFED Preferred Program Alternative.

It should be mentioned that some of the measures deleted from further consideration in this appendix for the purpose of ecosystem restoration might be determined in further studies to be suitable for helping mitigate potential adverse impacts of comprehensive alternative plans. Further, some measures or expansions of measures retained for further consideration also could be considered for mitigating adverse environmental and related impacts.

Measures Considered

Following is a brief discussion of the measures considered, which are separated into three categories: (1) improving cold-water and warm-water fisheries, (2) restoring and conserving riparian and wetland habitat, and (3) improving other fish and wildlife habitat. Rationale is included in this section for retaining or deleting measures. Also included are additional descriptions of the three measures retained for further consideration.

Table 2-4. Management Measures Addressing the Secondary Planning Objective of Conserving, Restoring, and Enhancing Ecosystem Resources

Management Measure	Potential to Address Planning Objective	Status/Rationale
Improve Cold-Water and Warm-Water Fishery Habitat		
Construct shoreline fish habitat around Shasta Lake	**Moderate to High** – Contributes to ecosystem restoration goals within watershed.	**Retained** – Would complement measures to increase storage in Shasta Lake.
Construct instream fish habitat on tributaries to Shasta Lake	**Moderate to High** – Contributes to ecosystem restoration goals within watershed.	**Retained** – Would complement measures to increase storage in Shasta Lake. High local interest.
Increase instream flows on the lower McCloud River	**Moderate** – Potential to benefit aquatic resources on lower McCloud River.	**Deleted** – Considerable impacts to hydropower.
Reduce acid mine drainage entering Shasta Lake	**Moderate** – Considerable benefit under certain hydrologic conditions.	**Deleted** – Considerable implementation, O&M, and liability issues. Encompassed within actions evaluated and prioritized under CALFED ERP.
Reduce motorcraft access to upper reservoir arms	**Moderate** – Potential to benefit fisheries in Shasta Lake.	**Deleted** – Motorcraft management is under the purview of USFS.
Increase instream flows on the Pit River	**Moderate** – Potential to benefit aquatic resources in upper Pit River.	**Deleted** – Considerable impacts to hydropower.
Restore and Conserve Riparian and Wetland Habitat		
Restore riparian and floodplain habitat along the Sacramento River	**High** – Directly contributes to ecosystem restoration along mainstem Sacramento River.	**Retained** – Would be compatible with other primary study objectives. Consistent with other restoration programs and projects in the primary study area. Encompassed within actions evaluated and prioritized under CALFED ERP.
Restore wetlands along the Fall River and Hat Creek	**Low** – Very low potential to contribute to ecosystem restoration in the Shasta Lake area.	**Deleted** – Considerably removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Conserve upper Pit River riparian areas	**Low** – Very low potential to contribute to planning objective.	**Deleted** – Considerably removed from primary study area. Independent action with low potential to contribute to other primary or secondary planning objectives.
Restore riparian and floodplain habitat along lower Clear Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Promote Great Valley cottonwood regeneration on Sacramento River	**Moderate –** Potential to contribute to planning objective.	**Deleted** – High uncertainty for Federal participation and potential to conflict with flood control requirements related to levee protection. Encompassed within actions evaluated and prioritized under CALFED ERP.
Conserve riparian corridor along Cow Creek	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Remove and control nonnative vegetation in the Cow Creek and Cottonwood Creek watersheds	**Moderate** – Indirectly supports planning objective.	**Deleted** – Limited ability to provide consistent and reliable benefits, compared with the other measures proposed. Independent action and would not directly contribute to improved ecological conditions along mainstem Sacramento River. Encompassed within actions evaluated and prioritized under CALFED ERP.
Improve Other Fish and Wildlife Habitat		
Create a parkway along the Sacramento River	**Moderate** – Can contribute to ecosystem restoration in the study area.	**Deleted** – Primarily focuses on land acquisition and conversion to public uses. As a project element, it would be a non-Federal responsibility with little direct Federal interest. Elements are a likely without-project condition.
Enhance forest management practices to conserve bald eagle nesting habitat	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Remove and control nonnative plants around Shasta Lake	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Control erosion and restore affected habitat in the Shasta Lake area	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted** – Likely a without-project condition; is an element of forest recovery plans by USFS.
Develop geographic information system for Shasta to Red Bluff reach	**Low to Moderate** – Can contribute to ecosystem restoration in study area.	**Deleted –** Would not directly contribute to other primary or secondary planning objectives. GIS mapping likely a without-project condition as part of other ongoing studies and projects.
Implement erosion control in tributary watersheds	**Moderate** – Indirectly supports planning objective.	**Deleted** – Considerable benefit to tributaries. Independent action and would not directly contribute to improved ecological conditions near Shasta Lake or along mainstem Sacramento River.

Key:
GIS = geographic information system
O&M = operations and maintenance
USFS = U.S. Forest Service

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Improve Cold-Water and Warm-Water Fishery Habitat The following measures were identified to improve cold-water and warm-water fishery habitat.

- **Construct shoreline fish habitat around Shasta Lake –** Many of the shallow, warm-water areas along the shoreline of Shasta Lake are capable of providing preferred habitat for juvenile fish and other adult resident fish species. The shorelines of most natural lakes and water bodies are lined with trees, rocks, debris, and other structures that provide cover. However, the shoreline of Shasta Lake is comparatively barren, which increases juvenile mortality. The lack of shoreline cover and suitable shallow-water fish habitat is due to several factors, including steep topography, soils, wave action, and seasonal water fluctuations in the lake. These factors cause erosion and prevent vegetation from becoming established within the lake drawdown area. This measure consists of improving shallow, warm-water habitat around the shoreline of Shasta Lake by planting resistant vegetation and placing large woody debris, boulders, and other aquatic "cover" structures within the drawdown area of the lake. This measure would not be universally applicable. It would be considered only at locations where the physical parameters (soils, slopes, existing vegetation, etc.) would allow. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in the Shasta Lake area. It would not conflict with any other ecosystem restoration measures that were preliminarily retained, nor would it conflict with other known programs or projects in the vicinity of Shasta Lake.

  This measure was retained for potential inclusion in concept plans primarily because it would be compatible with potential measures to raise Shasta Dam; habitat treatments could be extended, as needed, into the additional drawdown area.

- **Construct instream fish habitat on tributaries to Shasta Lake –** Tributary streams are an important environmental resource in the primary study area, supporting a variety of native and nonnative fish and other aquatic organisms. However, the quality and quantity of instream aquatic habitat has decreased over the last century because of the construction of dams, modification of stream hydrology, and other human influences. This measure consists of improving and restoring instream aquatic habitat on the lower reaches of key tributaries to Shasta Lake using various structural techniques to enhance fish passage and improve overall aquatic connectivity. It would not conflict with other known programs or projects in the vicinity of Shasta Lake.

  This restoration measure was retained for further consideration primarily because it would be compatible with potential measures to raise Shasta Dam and with other potential ecosystem restoration measures.

- **Increase instream flows on the lower McCloud River –** This measure consists of increasing releases from McCloud Dam for the purpose of increasing flows on the lower McCloud River. This measure would benefit fisheries on the lower McCloud River. Currently, McCloud Dam operations are part of the Pit-McCloud Hydroelectric Project. Water is exported from the McCloud River watershed through a tunnel to Iron Canyon Reservoir and from there to a powerhouse on the Pit River. Dam operations maintain minimum flows between 40 and 50 cfs on the lower McCloud River.

  This measure was deleted from further consideration for addressing the objective of ecosystem restoration primarily because of the considerable adverse impact on hydropower generation. However, it is a good example of a measure that may be reconsidered in the future to help mitigate adverse impacts.

- **Reduce acid mine drainage entering Shasta Lake –** This measure consists of remediating the residual adverse environmental impacts of abandoned former mining operations on aquatic conditions in Shasta Lake and its tributaries.

  This measure was deleted from further consideration because of numerous implementation issues, including high O&M requirements necessary for success and liability issues. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities (DFG et al. 2010). This measure may be reconsidered in the future to help mitigate adverse impacts.

- **Reduce motorcraft access to upper reservoir arms –** This measure consists of imposing additional boating and personal watercraft restrictions on portions of Shasta Lake.

  This measure was eliminated from further consideration primarily because motorcraft activity on Shasta Lake is already regulated by Federal and State boating laws, Shasta County, and USFS; additional regulations (if applicable) would be more appropriate as part of these existing programs.

- **Increase instream flows on the Pit River –** This measure consists of increasing instream flows on the lower Pit River to benefit native fish and aquatic habitat through performing power buy-outs, altering power generation operations, or removing selected water diversions or diversion facilities.

This measure was eliminated from further consideration primarily because of the considerable adverse impact on hydropower generation from these existing facilities.

Restore and Conserve Riparian and Wetland Habitat Seven measures were identified to restore and conserve riparian and wetland habitat. Each measure is described below.

- **Restore riparian and floodplain habitat along the Sacramento River –** Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento is limited between Keswick Dam and the RBPP. This is partially due to the natural topography and hydrology of the region; the Sacramento River is naturally more entrenched in this reach, and floodplains are narrow compared with the broad alluvial floodplains found lower in the Sacramento River system. This measure consists of restoring riparian and floodplain habitat at specific locations along the Sacramento River to promote the health and vitality of the river ecosystem. It would not conflict with other ecosystem restoration measures that were preliminarily retained or with other known programs or projects on the upper Sacramento River. The restoration would support the goals of the Sacramento River Conservation Area Forum, CALFED ERP, and other programs associated with riparian restoration along the Sacramento River.

  This measure was retained for further consideration primarily because it would have a high likelihood of success in accomplishing effective restoration and would indirectly benefit aquatic habitat conditions for anadromous fish.

- **Restore wetlands along the Fall River and Hat Creek –** This measure consists of restoring marshlands and wetlands along the Fall River and Hat Creek in the Pit River watershed. However, this measure is considerably removed from the primary study area and would not directly contribute to improved ecological conditions or habitat in the primary study area.

This measure was deleted from further consideration primarily because it is independent of hydraulic/hydrologic conditions in the primary study area and would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Conserve upper Pit River riparian areas –** This measure primarily consists of conserving high-value existing stands of riparian vegetation along the upper Pit River through acquiring environmental easements, and installing fencing and natural vegetation barriers around riparian corridors affected by grazing animals. However, this measure is considerably removed from the primary study area and would not directly contribute to improved ecological conditions or habitat in the primary study area.

  This measure was deleted from further consideration primarily because it is independent of hydraulic/hydrologic conditions in the primary study area and would not directly contribute to accomplishing the primary or other secondary planning objectives.

- **Restore riparian and floodplain habitat along lower Clear Creek –** This measure includes restoring floodplain and riparian habitat along lower Clear Creek.

  This measure would not directly contribute to improved ecological conditions along the upper Sacramento River. Hydrologic and hydraulic conditions on Clear Creek are independent of upper Sacramento River conditions. Habitat conditions in this tributary would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

  This measure was deleted from further development primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along the mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $22 million for river channel restoration and $46 million for riparian habitat restoration (DFG et al. 2010).

- **Promote Great Valley cottonwood regeneration on the Sacramento River –** This measure consists of actively supporting the Great Valley cottonwood regeneration concept along the Sacramento River. This includes working to replace lost floodplain sediment, recontouring floodplains that have disconnected from the river, and revegetating floodplain areas that could support Great Valley cottonwoods.

  This measure was deleted from further consideration primarily because (1) there would be major complexities associated with continuing Federal participation in an ongoing broad-scope program in the Sacramento Valley, and (2) potential to conflict with flood control requirements related to levee protection. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $46 million for riparian habitat restoration (DFG et al. 2010).

- **Conserve riparian corridor along Cow Creek –** This measure consists of protecting and conserving the riparian corridor along Cow Creek. It primarily includes acquiring environmental easements, installing livestock fencing, developing natural vegetation barriers, and replanting streamside grasses, shrubs, and trees.

  However, this measure would not directly contribute to improved ecological conditions along the upper Sacramento River. Hydrologic and hydraulic conditions on Cow Creek are independent of upper Sacramento River conditions. Habitat conditions in this tributary would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

  This measure was deleted from further development primarily because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along the mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. One of the CALFED ERP actions includes protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities, including $46 million for riparian habitat restoration (DFG et al. 2010).

- **Remove and control nonnative vegetation in the Cow Creek and Cottonwood Creek watersheds –** This measure consists of abating exotic vegetation in the Cow Creek and Cottonwood Creek watersheds through removing invasive species from riparian corridors. Periodic monitoring and reapplication of control measures would be required to maintain long-term benefits and effectiveness. In addition, this measure would likely have a limited ability to provide consistent and reliable benefits, compared with the other measures proposed.

  Furthermore, hydrologic and hydraulic conditions on these tributaries are independent of upper Sacramento River conditions. Habitat conditions in these tributaries would not benefit from other actions to improve Sacramento River habitat, including improved flow and water temperature conditions related to Shasta Dam releases. Therefore, this measure would not provide additional benefits (e.g., synergy) when combined with other potential measures related to Shasta Dam and Reservoir and their operation.

  This measure was deleted from further development primarily because it has limited ability to provide consistent and reliable benefits and because it is independent of hydraulic/hydrologic conditions in the upper Sacramento River, would not improve ecological conditions or fish habitat along the mainstem Sacramento River, and, therefore would not directly contribute to increasing anadromous fish survival within the primary Sacramento River study area. Furthermore, the ERP was included as part of the CALFED Preferred Program Alternative. This measure and similar activities were encompassed in the ERP action related to protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed, including the Sacramento River and its tributaries. The ERP has prioritized restoration actions and funded approximately $630 million of ecosystem restoration activities (DFG et al. 2010).

Improve Other Fish and Wildlife Habitat The following measures were identified to improve other fish and wildlife habitat.

- **Create a parkway along the Sacramento River –** Interest is growing in conserving public access to area rivers, lakes, streams, and other natural resources, and protecting their recreational, environmental, and aesthetic values. For instance, local groups have successfully established public parks and other ecosystem-focused conservation areas around Redding. This measure consists of establishing a natural, riverfront parkway along the Sacramento River near the Redding and Anderson urban areas to conserve riparian and floodplain habitat and promote habitat continuity along the river corridor. While this restoration would support the goals of the Sacramento River Conservation Area Forum, CALFED, and other programs, it is primarily focused on acquisition of lands and land rights, and converting existing uses to those supporting public uses. Because of the high focus on land acquisition, there would be little known Federal interest and small potential to contribute to the primary or other secondary planning objectives of the SLWRI. In addition, elements of this measure are being implemented as part of other programs, and this measure is likely a without-project condition. Accordingly, this measure was deleted from further consideration in the SLWRI.

- **Enhance forest management practices to conserve bald eagle nesting habitat –** This measure consists of enhancing bald eagle nesting habitat at various locations around Shasta Lake through forest management practices, including thinning, applying insecticides to reduce mortality from bark beetles and other pests, control stocking in conifer stands to encourage growth of large trees, and managing underbrush to protect important stands from wildfires.

  This measure was deleted from further consideration primarily because it is a likely without-project condition.

- **Remove and control nonnative plants around Shasta Lake –** This measure consists of removing and controlling nonnative species at various locations around Shasta Lake primarily through herbicides, physical removal, or controlled burning.

  This measure was deleted from further consideration primarily because it is a likely without-project condition. Also, it is similar to programs being implemented in the study area by USFS.

- **Control erosion and restore affected habitat in the Shasta Lake area –** This measure consists of restoring highly erodible lands in the Sacramento River and Pit River watershed near Shasta Lake that have been impacted by timber harvest, historic smelter blight, and other human activities.

  This measure was deleted from further consideration primarily because it is a likely without-project condition. Also, it is similar to programs being implemented in the study area by USFS.

- **Develop geographic information system for Shasta to Red Bluff reach –** This measure consists of developing a geographic information system (GIS) for the Sacramento River and tributaries between Shasta Dam and the RBPP.

  This measure was deleted from further consideration primarily because (1) it would not directly contribute to accomplishing the primary planning objectives and (2) GIS-based mapping is being developed by numerous regional studies and local entities.

- **Implement erosion control in tributary watersheds –** This measure consists of implementing local erosion control projects in watersheds tributary to the Sacramento River to prevent loss of key floodplain and riparian habitat, and to conserve the quality of aquatic habitat impaired by excessive sediment input.

  This measure was deleted from further consideration as a potential restoration element primarily because it would not contribute to improved ecological conditions near Shasta Lake or along the upper Sacramento River and would not directly contribute to accomplishing the primary or other secondary planning objectives.

Measures Retained for Further Consideration

Each of the three management measures retained to address the secondary objective of ecosystem restoration in the Shasta Lake vicinity and along the Sacramento River downstream from Shasta Dam were considered in greater detail to determine how they might become components of concept plans. The locations of the retained measures are shown in Figure 2-6 and described below in terms of their major components, and accomplishments.

- **Construct shoreline fish habitat around Shasta Lake –** The shorelines of most natural lakes and water bodies are lined with trees, rocks, debris, and other structures that provide aquatic cover. But the shoreline of Shasta Lake and other reservoirs is comparatively barren, increasing juvenile fish mortality. The lack of shoreline cover and suitable shallow water fish habitat is due to several factors, including the steep topography, soils, wave action, and seasonal water fluctuations in the reservoir. These factors cause erosion and prevent vegetation from becoming established within the reservoir drawdown area. In addition, large woody debris entering the lake from its tributaries is removed annually due to boating concerns. Shallow, warm-water areas along the shoreline of Shasta Lake provide preferred habitat for juvenile fish and other adult resident fish species. This measure would improve shallow, warm-water fish habitat at specific locations around the shoreline of Shasta Lake using resilient vegetation and aquatic “cover” structures within the upper drawdown area of the lake.

This measure would involve (1) installing artificial fish cover, including complex woody structures, (2) planting water-tolerant and/or erosion-resistant vegetation at prescribed locations within the reservoir drawdown area, and (3) performing selective reservoir rim clearing of specific trees and vegetation. Applications would be chosen, as appropriate, for site-specific shoreline conditions, taking into consideration bank slope, rate of erosion, proximity to tributaries, soils, and the presence of existing cover or vegetation. It is estimated that about 20 structures and approximately 400 selective plantings would be required for each acre of shoreline restored. The estimated life of the artificial cover structures could depend on the type of structure.

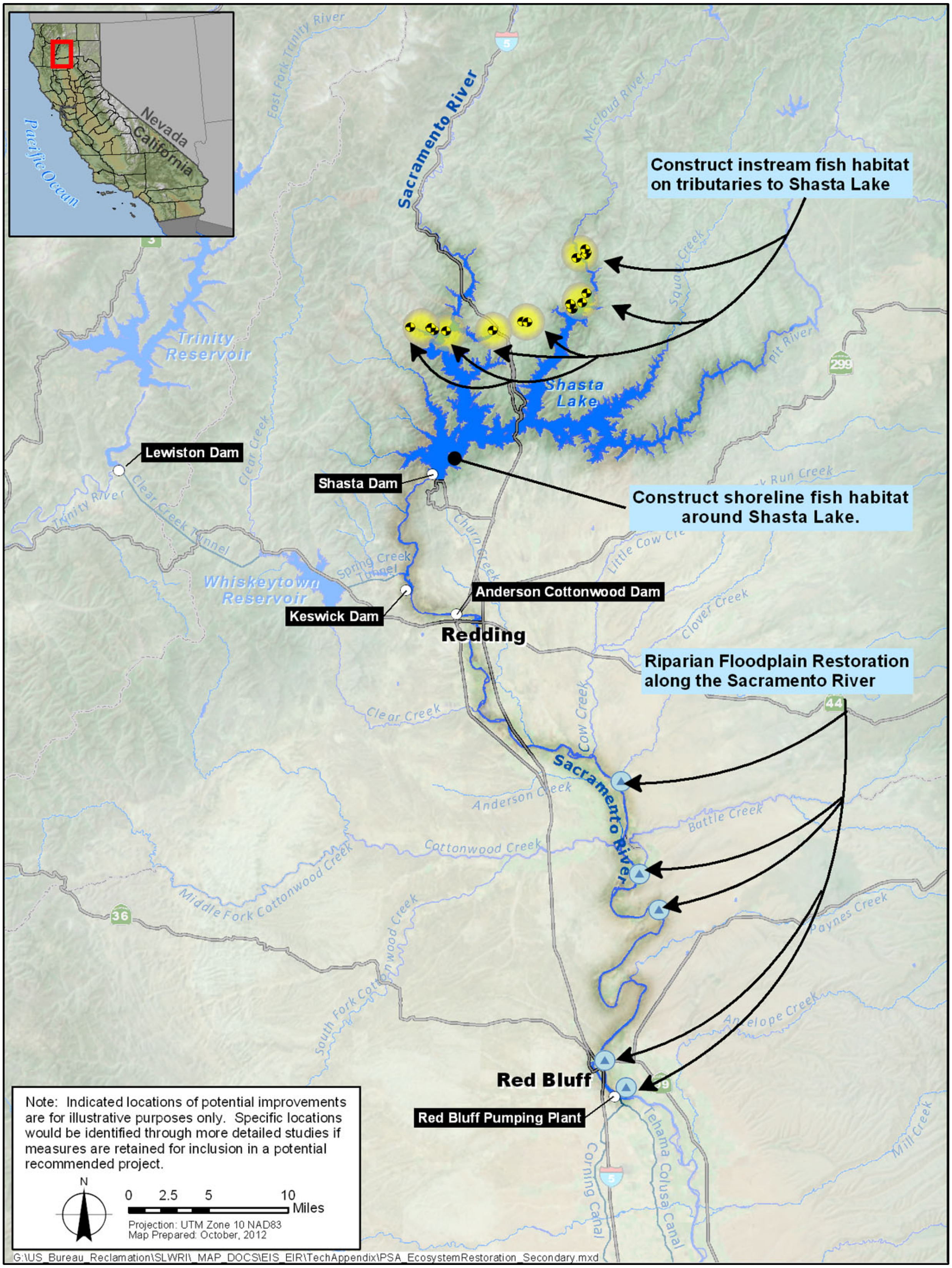

Figure 2-6. Measures Retained to Address Secondary Planning Objective – Ecosystem Restoration

It is estimated that locations near the mouths of tributaries would be targeted for restoration because their lower reaches provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Further, fishermen and other recreational users favor the mouths of tributaries. Shoreline areas with gradual slopes provide a wider, shallow-habitat area and would be more appropriate than steep banks that are prone to accelerated erosion. In addition, the sites would need to be undeveloped, provide reasonable construction access, and not be subject to considerable recreational disturbances (i.e., adjacent to marinas, picnic areas, campgrounds, or other areas that attract large numbers of people). Several major and minor tributaries to Shasta Lake appear to have a high potential for application of this measure. For the purpose of this initial evaluation, it is estimated that sites at the mouths of eight perennial tributaries would be selected with approximately 5 acres of shoreline suitable for restoration at each site. Other areas also may have a high potential and would be evaluated in future studies.

Major accomplishments of this measure would be to (1) increase the survival of juvenile fish by improving the quantity of available cover and overall quality of shallow-water habitat, and (2) benefit land-based species that inhabit the shoreline of Shasta Lake through establishing resilient vegetation. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in the Shasta Lake area. Increased shallow-water fish survival also would enhance recreational sportfishing opportunities in the lake.

Potential measures to raise Shasta Dam would increase the reservoir drawdown area that is subject to erosion and other factors that diminish shoreline habitat. This measure would complement measures to raise Shasta Dam because shoreline habitat treatments could be extended, as needed, into the additional drawdown area. This measure does not conflict with any other ecosystem restoration measures that were preliminarily retained, nor does it conflict with other known programs or projects in the vicinity of Shasta Lake.

The estimated certainty of the measure in achieving its intended accomplishments is moderate, primarily because numerous factors affect the sustainability of habitat within the drawdown area of the lake. An adaptive management approach that would monitor and modify restoration elements would improve the likelihood of success.

- **Construct instream fish habitat on tributaries to Shasta Lake –** Tributary streams are an important environmental resource in the primary study area, supporting a variety of native and nonnative fish and other aquatic organisms. However, the quality and quantity of instream aquatic habitat has decreased over the last century because of construction of dams, modification of stream hydrology, and other human influences. The quantity and quality of aquatic habitat in the tributaries of Shasta Lake are influenced primarily by the presence of road crossings and culverts, although in some cases other structures or grade controls (e.g., transitional deltaic deposits) may constitute barriers to aquatic connectivity, including fish passage. Barriers may also be created by adverse water quality conditions, particularly high water temperature or toxic materials. This measure would conserve and/or restore instream aquatic habitat on the lower reaches of key tributaries to Shasta Lake (see Figure 2-6).

Two categories of potential aquatic habitat enhancement in tributaries are discussed below: (1) identifying and correcting barriers to fish passage that are critical to various life stages for native fish species, particularly at culverts and other human-made barriers, and (2) identifying and implementing feasible aquatic habitat improvements intended to conserve or restore degraded aquatic and riparian habitat in tributaries to Shasta Lake.

Fish passage improvements include restoring and/or enhancing a minimum of five perennial stream crossings to help enable upstream and downstream passage for all life stages of native fish in Shasta Lake. Barriers to fish passage in the watersheds above Shasta Lake are primarily associated with culverts or other types of stream crossings. Typical passage problems created by culverts and other road crossings are as follows:

– Excessive drop at the downstream end of a crossing (perched outlet)

– Water velocities within the crossing that are too fast for fish to swim upstream

– Constriction of flow as it enters a crossing, causing excessive water velocities and turbulence at the inlet

– Lack of sufficient water depth in a culvert for fish to swim

– Debris accumulation across an inlet or within a culvert

Aquatic habitat restoration includes efforts to reestablish or enhance aquatic connectivity, and reestablish or conserve riparian vegetation needed to provide shade, cover, and organic material. Additionally, aquatic habitat restoration includes reducing sediment and other pollutants associated with roads and other human-made disturbances from discharging into streams flowing into Shasta Lake. These opportunities are consistent with recommendations developed in watershed assessments prepared by the STNF for lands in close proximity to Shasta Lake. The watershed assessments identify roads, specifically stream crossings, as opportunities for enhancing aquatic connectivity and reducing the impacts of road-related sediment on aquatic habitat. As with other elements of the aquatic enhancement program, it is anticipated that additional site evaluations would be conducted to prioritize opportunities based on available funding.

The lower reaches of intermittent and perennial streams tributary to Shasta Lake that support aquatic organisms native to the upper Sacramento River would be targeted for aquatic restoration under this measure because they provide year-round fish habitat. Although up to nearly 20 miles of stream could be considered for this measure, initial implementation would likely be restricted to larger tributaries, after which the potential to expand to smaller tributaries could be assessed. For this measure, it is estimated that instream aquatic restoration would be performed along a total of 8 miles of stream, or about 2 miles along the lower reaches of each of the four major tributaries to Shasta Lake. It is estimated that many of the restoration activities would be conducted on Federal lands.

Major accomplishment of this measure would be to improve the quality and availability of aquatic habitat on tributary streams. This measure would support the secondary planning objective of conserving and restoring ecosystem resources in Shasta Lake. Both native and nonnative fish would benefit, including some lake fish that spawn on the lower reaches of the tributaries. It could also benefit steelhead, a native species that must be planted in the lake annually, as some natural reproduction occurs on the lower reaches of the tributaries to Shasta Lake. Improving aquatic habitat also would enhance recreational sportfishing opportunities in the area.

This restoration measure would complement potential efforts to restore shoreline fish habitat in Shasta Lake because many juveniles that use shoreline habitat hatch on the lower reaches of the tributaries. Thus, improving and restoring aquatic habitat on the tributaries would increase the number of juveniles entering Shasta Lake. This measure would be compatible with potential measures to raise Shasta Dam and does not conflict with any other ecosystem restoration measures that were preliminarily retained. This measure does not conflict with other known programs or projects in the vicinity of Shasta Lake.

The estimated certainty of this measure in achieving its intended accomplishments is high. Most of the major tributaries to Shasta Lake are highly regulated, reducing the potential for improvements to be damaged or destroyed during extreme flow events. Similar activities have been accomplished with success on other similar stream systems.

CDFW, the Cantara Trust, and the Coordinated Resource Management Plan group have participated in similar restoration activities in Shasta County. Restoration actions should be coordinated with local restoration groups, tribes, landowners, and CDFW, as appropriate.

- **Restore riparian and floodplain habitat along the Sacramento River –** Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that improve the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. These areas are seasonally flooded on a frequent basis, interacting with dynamic river processes such as erosion and deposition. Riparian and floodplain terrace habitat along the Sacramento River is limited between Keswick Dam and the RBPP. This measure consists of restoring riparian and floodplain habitat at specific locations along the Sacramento River to promote the health and vitality of the river ecosystem (see Figure 2-6).

  This measure would involve acquiring and revegetating floodplain terraces and adjacent riparian areas with native plants. Suitable locations for restoration would be in areas with a 20 percent to 50 percent chance of flooding in any year (commonly referred to as 5-year to 2-year floodplains). Locations near the confluences of perennial creeks and streams tributary to the Sacramento River would have potential to provide maximum benefits. Continuity is also important to the health and vitality of riparian areas; small, isolated patches of riparian habitat tend to be less productive than larger, continuous stretches of habitat. It is estimated that a limited amount of land contouring and imported fill material would be required at several locations where the historic floodplain has been disconnected from the river or disturbed by human activity.

  For the purpose of this preliminary evaluation, it is estimated that a total of 500 acres would be restored at one or more sites. Planting mix, composition, and density would be determined by a more detailed site analysis, but could include native cottonwood, willow, box elder, valley oak, western sycamore, elderberry, and a variety of understory brush species. Temporary irrigation would be provided on an as-needed basis. The revegetated areas are expected to develop into self-sustaining riparian habitats within 1 to 4 years of initial planting, based on results of previous riparian restoration projects along the Sacramento River. Regraded floodplain areas are expected to change over time depending on hydrologic conditions, but it is anticipated that no elements of this measure would need to be replaced or reapplied during the 50-year project life. The site would be fenced to reduce the potential for access by livestock.

This measure would involve land acquisition, floodplain contouring and other earthwork, and revegetation. There appears to be local support for this type of restoration project along the Sacramento River. The primary accomplishment of this measure would be to restore native riparian habitat and associated floodplain lands. This measure would support the secondary planning objective of conserving and restoring ecosystem resources along the upper Sacramento River. Riparian habitat contributes to species diversity, water quality, and the quality of instream aquatic habitat, providing shade and a source of woody debris. In this manner, this measure indirectly supports the primary planning objective of increasing the survival of anadromous fish on the Sacramento River. The estimated certainty of this measure achieving the intended accomplishments is very high. Similar restoration projects along the Sacramento River have provided favorable, sustainable results.

This measure would combine favorably with potential measures to modify Shasta Dam because operational changes could benefit the natural riverine processes that drive sustainable riparian habitat regeneration. This measure would not conflict with other ecosystem restoration measures preliminarily retained, or other known programs or projects on the upper Sacramento River. Restoration would support the goals of the Sacramento River Conservation Area Forum, CALFED, and other restoration programs.

Reduce Flood Damage

Of five management measures identified to help reduce flood damages and contribute to public safety along the Sacramento River, two were initially retained for further development and possible inclusion in concept plans (Table 2-5). Of those two initially retained measures, one was carried forward for incorporation in comprehensive plans. Following is a brief description of the measures and rationale for retaining or deleting measures.

Table 2-5. Management Measures Addressing the Secondary Planning Objectives of Reducing Flood Damage, Developing Additional Hydropower Generation, Maintaining and Increasing Recreation, and Maintaining or Improving Water Quality

Management Measure	Potential to Address Planning Objective	Status/Rationale
Reduce Flood Damage		
Update Shasta Dam and Reservoir flood management operations	**Moderate to High** – Directly contributes to planning objective.	**Retained** – Compatible with any potential modification of Shasta Dam and Reservoir. Potential to realize an increase in flood control with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning constraints/criteria.
Increase flood management storage space in Shasta Reservoir	**Moderate** – Considerable potential to further reduce peak flows on upper Sacramento River; however, low potential to reduce flood damages due to the relatively high level of protection from existing facilities.	**Deleted** – Would conflict with the primary planning objectives. Estimated low potential for economic justification (costs are expected to exceed benefits). For increased space via raising Shasta Dam, it is expected that dam raise construction costs would considerably exceed flood control benefits. For space increase through reoperation, expected costs to replace reduction in water reliability would also considerably exceed flood control benefits.
Implement nonstructural flood damage reduction measures	**Moderate** – Partially contributes to planning objective.	**Deleted** – Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Implement traditional flood damage reduction measures	**Moderate** – Partially contributes to planning objective.	**Deleted** – Independent action and not directly related to accomplishing the primary or other secondary planning objectives.
Route PMF from top of conservation pool	**Moderate to High** – Directly contributes to public safety issues at Shasta Dam.	**Deleted** – This measure already is consistent with existing reservoir conditions and operations, making further changes unnecessary.
Develop Additional Hydropower Generation		
Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head	**Moderate to High** – Directly contributes to planning objective.	**Retained** – Potential to realize an increase in hydropower output from Shasta with increasing size of Shasta Reservoir for primary planning objectives. Would not conflict with other secondary planning objectives or planning constraints/criteria.
Construct new hydropower generation facilities	**Moderate** – Directly contributes to planning objective.	**Deleted** – This measure would directly contribute to the secondary planning objective but it is an independent action and not directly related to accomplishing the primary planning objectives. Although potential to realize additional hydropower benefits with increased/replaced hydropower facilities, could be pursued regardless of primary planning objectives.

Table 2-5. Management Measures Addressing the Secondary Planning Objectives of Reducing Flood Damage, Increasing Hydropower, Maintaining and Increasing Recreation, and Maintaining or Improving Water Quality (contd.)

Management Measure	Potential to Address Planning Objective	Status/Rationale
Maintain and Increase Recreation Opportunities		
Maintain and enhance recreation capacity, facilities, and opportunities	**High** – Would directly contribute to planning objective.	**Retained** – Considerable potential to be added to alternatives to directly benefit recreation.
Develop new NRA recreation plan	**Low to Moderate** – Although contribute to planning objective, likely scope would be much greater.	**Deleted** – Developing a new NRA recreation plan is a completely separate process and should be pursued under that process. Scope is far beyond recreation being added as an increment to a water resources plan with the identified primary planning objectives for SLWRI.
Reoperate reservoir for recreation	**High** – Would directly contribute to planning objective.	**Retained** – Considerable potential to be added to alternatives to directly benefit recreation.
Maintain or Improve Water Quality		
Improve operational flexibility for Sacramento-San Joaquin Delta water quality by increasing storage in Shasta Reservoir.	**Moderate** – Would contribute to secondary planning objective	**Retained** – Potential to contribute to the secondary planning objective of maintaining or improving water quality conditions in the Sacramento River downstream from Shasta Dam and the Delta.

Key:
NRA = National Recreation Area
PMF = probable maximum flood
SLWRI = Shasta Lake Water Resources Investigation

- **Update Shasta Dam and Reservoir flood management operations –** This measure consists of revising the established rules for operating Shasta Dam and Reservoir for flood management. This measure would include reassessing existing seasonal flood control storage space needs at Shasta using updated information on regional hydrologic and meteorological conditions and rainfall/runoff characteristics in the drainage basin. Potential methods to improve flood control would include improved long-range weather forecasting, implementing additional forecast-based reservoir drawdown to provide additional space for anticipated high-flow events, changing criteria regarding the rate of outflows from Shasta Dam for flood control, and modifying target peak flows at Bend Bridge.

  This measure was retained for further consideration primarily because it would be compatible with any potential modification of Shasta Dam and Reservoir. It would not conflict with other secondary planning objectives, planning constraints, or criteria. As with reoperation for water supply reliability, although the concept of this measure is being retained for further development, its specific features and their influence on water supply reliability and flood damage reduction would not be developed until detailed operational modeling can be accomplished in further investigations as part of detailed alternative plan formulation in the SLWRI.

- **Increase flood management storage space in Shasta –** This measure consists of increasing the flood control storage space in Shasta Reservoir primarily through raising the dam or reducing water conservation storage space. A variation would be to substitute water conservation storage space in Shasta with storage in another reservoir, such as the NODOS project, and use vacant seasonal space in Shasta for increased flood control. However, it is estimated that potential flood damage reduction benefits to be gained from either action would be far less than the costs to create increased storage space, either in Shasta Reservoir or other facilities. For increased space resulting from raising Shasta Dam, it is estimated that the cost to raise the dam would considerably exceed potential flood control benefits. For space increase through reoperation, the expected costs to replace reduction in water reliability would also considerably exceed flood control benefits.

  This measure was deleted from further consideration primarily because it would likely conflict with the primary planning objectives. In addition, it would not be economically feasible (costs are expected to exceed benefits).

- **Implement nonstructural flood damage reduction measures –** Typical nonstructural (or nontraditional) flood damage reduction measures can include (1) flood-proofing (temporary or permanently closing structures, raising existing structures, and constructing small walls or levees around structures), (2) floodplain evacuation (moving structures and their contents to safer sites), (3) development of restrictions (restricting future building in flood-prone areas), and (4) flood warning (flood forecasting, warning, evacuation, and post-flood reoccupation and recovery).

This measure was deleted from further consideration primarily because it is an independent action and would not be directly related to accomplishing the primary or other secondary planning objectives. Also, programs are already in place through Federal and State agencies to address flood hazard mitigation.

- **Implement traditional flood damage reduction measures –** Various structural methods to reduce flood damages include constructing levees or modifying the flood-carrying capacity of a river system.

  This measure was deleted from further consideration primarily because it is an independent action and would not be directly related to accomplishing the primary or other secondary planning objectives. Also, programs are already in place through Federal and State agencies to address flood hazard mitigation.

- **Route Probable Maximum Flood from top of conservation pool –** Shasta Dam can safely pass the computed Probable Maximum Flood (PMF). However, routing the PMF from the top of the conservation pool (4.5 MAF) would provide an additional margin of public safety in the event of an extremely rare flood event approaching or equaling the PMF.

  This measure was initially retained for development in concept plans, then deleted from further consideration during the comprehensive plan phase. Subsequent evaluation showed that existing reservoir operations and conditions already were consistent with this measure, making it unnecessary.

Develop Additional Hydropower Generation

Two measures were considered to increase hydropower potential in the study area (see Table 2-5). Following is a brief description of each measure:

- **Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased hydraulic head –** This measure consists of modifying the hydropower generation facilities at Shasta Dam to take advantage of any increases in water surface elevations resulting from enlarging the dam, if applicable. Nearly all releases from Shasta and Keswick Dams are made through their generating facilities. On occasion, however, outflows during flood operations are made through the flood control outlets and over the spillway. During these instances, the existing powerplant is bypassed for much of the flood control (space evacuation) release. Power generated during these brief and infrequent periods generally has a lower value due to usually abundant supplies during winter periods. Raising Shasta Dam would allow the potential to reduce these flood releases in winter and allow water to pass through the generators later in the year when the water is usually more valuable. Further, with higher water surface elevation, greater energy levels (head) would be available for operating the turbines. With the greater total head, the existing power facilities, including turbines and penstocks, may need to be replaced, especially with large dam raises (e.g., 100- or 200-foot raises).

This measure was retained for consideration as part of concept plans that include modifying Shasta Dam.

- **Construct new hydropower generation facilities –** This measure consists of constructing new hydropower facilities at Shasta Dam to increase the electrical generation capabilities from the project.

  This measure was deleted from further consideration primarily because it would not contribute either directly or indirectly to addressing the primary planning objectives and because it can be accomplished independently of modifying Shasta Dam and Reservoir.

Maintain and Increase Recreation Opportunities

Recreation is not a specific purpose to the Shasta Division of the CVP. No formal recreation facilities were developed as part of the original project. However, in Public Law 89-336 (8 November 1965), Congress established the Whiskeytown-Shasta-Trinity National Recreation Area (NRA). Resulting from that act and subsequent direction, nearly all lands surrounding Shasta Lake that were acquired for the construction and operation and maintenance of Shasta Dam and Reservoir are now within the NRA. Recreation-related activities on these lands and on Shasta Lake are administered by USFS under its responsibility to manage the NRA.

Increasing the storage in Shasta Lake would provide a larger water surface for recreation than exists today. Conversely, the larger lake area would also adversely impact some of the existing facilities and activities. It is believed that Reclamation has the authority to increase the size of Shasta Dam and Reservoir without the requirement to mitigate for adverse impacts to the existing Federal recreation-related facilities. However, doing so would be counterproductive to the planning objectives of maintaining and increasing recreation opportunities at Shasta Lake. In addition, raising Shasta Dam and Reservoir would also provide opportunities to improve recreation resources in the area.

Accordingly, the following general measures were identified to help maintain and increase recreation opportunities at Shasta Lake:

Maintain and Enhance Recreation Capacity, Facilities, and Opportunities

Major recreation activities at Shasta Lake include the following:

- Water skiing/wakeboarding
- Using personal watercraft
- Fishing
- Houseboating
- Canoeing/kayaking
- Swimming

Water-related land activities include the following:

- Camping
- Hiking and backpacking
- Wildlife viewing
- Picnicking
- Interpretive program

Recreation is not a specific purpose of the Shasta Division of the CVP, and no formal recreation facilities were developed as part of the original project. However, in 1965, Congress established the Whiskeytown-Shasta-Trinity NRA. As a result of that act and subsequent direction, USFS manages recreation within the NRA, which includes managing numerous water resources and related recreation activities at Shasta Lake. Increasing the storage in Shasta Lake would provide a larger water surface for recreation.

This measure would focus on maintaining existing recreation capacity at Shasta Dam and Lake through relocating and modernizing recreation facilities adversely affected by a higher lake level. It also includes enhancing opportunities related to the larger lake surface and modernized recreation facilities. This measure was retained for further development in the SLWRI.

- **Develop New NRA Recreation Plan –** USFS has indicated a desire to update the existing plan for the Whiskeytown-Shasta-Trinity NRA. USFS would like to use the opportunity created by raising Shasta Dam and Reservoir for that purpose. It is believed, however, that developing, coordinating, and implementing a new NRA plan is a separate Federal action and far outside the scope of the SLWRI. Accordingly, this measure was deleted from further consideration in the SLWRI.

- **Reoperate Reservoir for Recreation –** This measure consists of changing the established rules for operating Shasta Dam and Reservoir for flood management to benefit recreation resources on Shasta Lake. A claim by many of the recreation interests around Shasta Lake is that often the lake is forced to draw down in early spring for flood control and then, because of limited inflows the remainder of the season, the lake cannot recover, which adversely impacts recreation (as well as water supply). Locals cite 2004 as an example. They also claim that the existing reservoir operation rules for flood control are outdated (based on a USACE report dated 1977, nearly 30 years ago) and that by using more recent data and current technologies, the drawdown would not be required in some years, or would not be as significant. There is limited potential for changes in flood management rules to allow for more operational flexibility in reservoir drawdown requirements in response to storms with improved advanced forecasting. Additionally, with an increase in reservoir depth due to raising Shasta Dam, reservoir reoperation would likely include raising the bottom of flood control pool elevation, allowing for higher winter and spring water levels.

  This measure was retained for further consideration primarily because it may be compatible with any potential modification of Shasta Dam and Reservoir. In addition, it would likely be compatible with other primary and secondary planning objectives.

Maintain or Improve Water Quality

One management measure was considered to maintain or improve water quality in the study area (see Table 2-5). Following is a brief description of the measure, which was retained for further consideration:

- **Improve operational flexibility for Delta water quality by increasing storage in Shasta Reservoir –** This measure consists of providing improved operational flexibility for Delta water releases by providing additional storage in Shasta Reservoir. Shasta Dam has the ability to provide increased releases, as well as high flow releases, to reestablish Delta water quality. Improved Delta water quality conditions could provide benefits for both water supply reliability and ecosystem restoration by potentially increasing Delta outflow during drought years, and reducing salinity during critical periods.

  This measure was added to the comprehensive plans and was retained primarily because it had the potential to meet the secondary planning objective of maintaining or improving water quality conditions in the Sacramento River downstream from Shasta Dam and the Delta.

Measures Summary

Tables 2-6 and 2-7 summarize the management measures that were carried forward for potential inclusion in concept plans to address the primary and secondary planning objectives, respectively. Those carried forward are believed to best address the objectives of the SLWRI, with consideration of planning constraints and criteria. It should be noted that measures that have been dropped from consideration at this stage might be reconsidered in the future as mitigation measures or other plan features. Similarly, additional measures not considered herein may be added to alternative plans as they are formulated.

Table 2-6. Measures Retained to Address the Primary Planning Objectives

Primary Planning Objective	Management Measure	
Increase Anadromous Fish Survival	Restore Spawning Habitat (Abandoned Gravel Mines)[1]	Restore abandoned gravel mines along the Sacramento River.
	Construct Instream Aquatic Habitat	Construct instream aquatic habitat downstream from Keswick Dam
	Replenish Spawning Gravel	Replenish spawning gravel in the Sacramento River.
	Modify TCD	Make additional modifications to Shasta Dam for temperature control.
	Enlarge Shasta Lake Cold-Water Pool	Enlarge Shasta Dam and Reservoir to increase the cold-water pool in the lake to increase anadromous fish survival.
	Modify Storage and Release Operations at Shasta Dam	Modify storage and release operations at Shasta Dam to benefit anadromous fish
Increase Water Supply and Supply Reliability	Increase Conservation Storage	Increase conservation storage space in Shasta Reservoir by raising Shasta Dam.
	Conjunctive Water Management[1]	Develop conservation groundwater storage near the Sacramento River downstream from Shasta Dam.
	Reoperate Shasta Dam	Increase the effective conservation storage space in Shasta Reservoir by increasing the efficiency of reservoir operation for water supply reliability.
	Reduce Demand	Identify and implement, to the extent possible, water use efficiency methods.

Note:
[1] These measures were retained for development in concept plans in the initial alternatives phase, but were later eliminated from further consideration during the comprehensive plans phase.
Key:
TCD = temperature control device

Table 2-7. Measures Retained to Address the Secondary Planning Objectives

Secondary Planning Objective	Management Measure	
Conserve, Restore, and Enhance Ecosystem Resources	Restore Shoreline Aquatic Habitat	Construct shoreline fish habitat around Shasta Lake.
	Restore Tributary Aquatic Habitat	Construct instream fish habitat on tributaries to Shasta Lake.
	Restore Riparian Habitat	Restore riparian and floodplain habitat along the upper Sacramento River.
Reduce Flood Damage	Modify Flood Operations Guidelines	Update Shasta Dam and Reservoir flood management operations to improve system-wide reliability and public health and safety.
	Route PMF From Top of Conservation Pool[1]	Route the Probable Maximum Flood from the top of the conservation pool in Shasta Reservoir.
Develop Additional Hydropower Generation	Modify Hydropower Facilities	Modify existing/construct new generation facilities at Shasta Dam to take advantage of increased head.
Maintain and Increase Recreation	Maintain and Enhance Recreation Facilities	Maintain and enhance recreation capacity, facilities, and opportunities.
	Reoperate Reservoir	Increase recreation use by stabilizing early season filling in Shasta Lake.
Maintain or Improve Water Quality	Increase Operational Flexibility	Improve operational flexibility for Delta water quality by increasing storage in Shasta Reservoir.

Notes:
[1] These measures were retained for development in concept plans in the initial alternatives phase, but were later eliminated from further consideration during the comprehensive plans phase.
Key:
PMF = Probable Maximum Flood

Chapter 3 Shasta Dam and Reservoir Enlargement Scenarios

This chapter summarizes information developed on enlargement scenarios for Shasta Dam and Reservoir and identifies potential sizes recommended for further development into concept plans.

In the 1999 Reclamation report titled *Appraisal Assessment of the Potential for Enlarging Shasta Dam and Reservoir* (Reclamation 1999), an evaluation was made of the major features, issues, and costs associated with three potential raise scenarios for Shasta Dam and Reservoir: Low-Raise Option (6.5-foot raise), Intermediate-Raise Option (102.5-foot raise), and High-Raise Option (202.5-foot raise). Information from the report was reviewed and is summarized in this appraisal-level assessment.

A breakpoint analysis was conducted in early 2003 to identify the elevations of Shasta Dam raises for which implementation costs would considerably change due to the need for relocations or modifications of major project features (Reclamation 2004a). The analysis identified two fundamental cost components associated with raising Shasta Dam and enlarging Shasta Reservoir: (1) modifying the main dam and appurtenances and (2) modifying reservoir infrastructure and facilities. It was concluded in the analysis that the first major breakpoint in costs for increasing the size of Shasta Reservoir would occur with a top-of-full-pool raise from elevation 1,067 to about elevation 1,087.5 (20.5-foot raise), which would correspond to a dam raise of about 18.5 feet. This is primarily due to the need to relocate the Pit River Bridge with dam raises greater than about 18.5 feet. The second major breakpoint would occur with a top-of-full-pool raise to about elevation 1,100, which would correspond to a dam raise of about 30 feet. Raises of up to about 30 feet could likely be accomplished by raising the existing dam crest while higher dam raises would require increasing the dam mass, and constructing cofferdams and other facilities. Accordingly, two additional dam raise scenarios (approximately 18.5 and 30 feet) were developed in an effort to assess the relationship between the height of a dam raise and resulting cost of new water supplies.

Information is presented below on (1) rationale for establishing a dam raise of 18.5 feet and (2) the three scenarios included in the 1999 report and two expanded low-level dam raise scenarios. Also included is a comparison of the various dam raise scenarios.

Rationale for 18.5-Foot Dam Raise

As mentioned, it is estimated that the Pit River Bridge would need to be relocated for Shasta Dam raises greater than about 18.5 feet. A dam raise of 18.5 feet would allow for an increase in the full pool by about 20.5 feet or from elevation 1,067 to about elevation 1,087.5. Even with dam raises up to 18.5 feet, considerable modifications would need to be made to two piers of the bridge. These modifications are described in the Engineering Summary Appendix.

Figure 3-1 shows an elevation view of the Pit River Bridge south Abutment Number 2. Correspondence from the Union Pacific Railroad (UPRR) identified a minimum clearance between the low cord of the bridge and an increased water surface of 4 feet. The lowest point of the Pit River Bridge is at the south end of the structure. For this project, a minimum clearance of 1 foot below the south abutment bearing attachment to the main bridge structure was selected. This would allow a minimum clearance of 4.5 feet between the new full pool elevation and the main bridge structural elements.

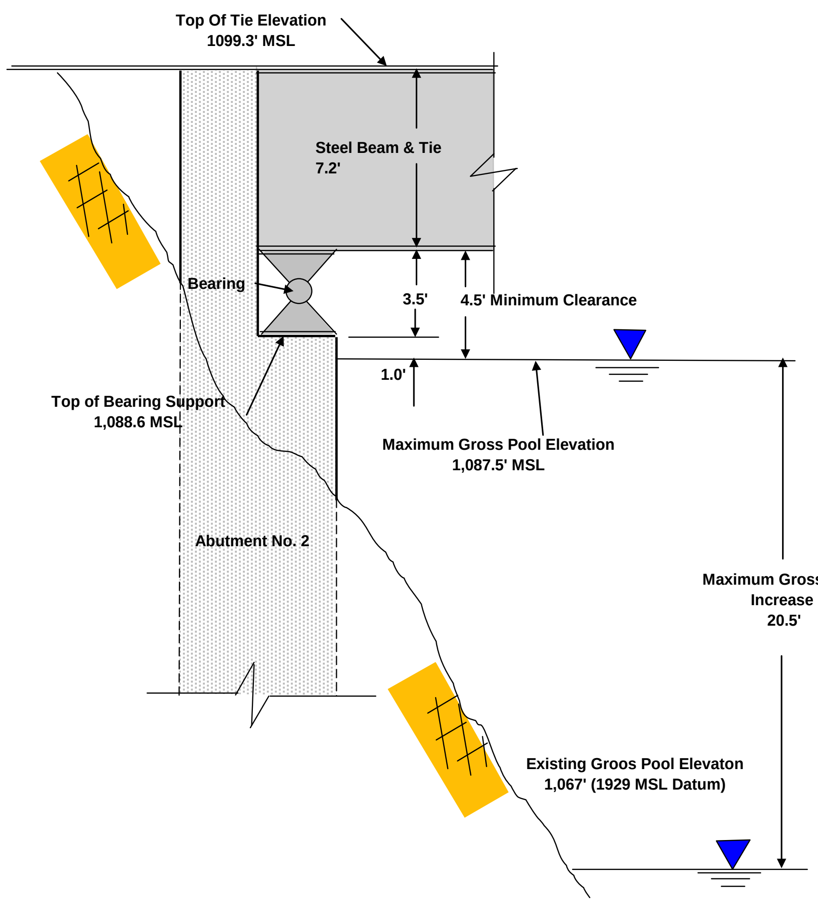

Figure 3-1. Elevation Sketch Showing the South End of the Pit River Bridge with Respect to the Existing and Increased Full Pool Elevation at Shasta Lake

It should be mentioned that storage in Shasta Reservoir, with or without raising the dam, is expected to reach full pool elevation in the future about as often it has in the past. This occurs to about once every 3 to 4 years, after the flood season, usually in May and/or early June. Durations would be only several days at the maximum elevation, but the high water condition could last several weeks. The south end of the Pit River Bridge is about 11 feet lower than the north end of the structure. Accordingly, the likely minimum clearance between the bridge and full pool elevation available for boat traffic during high water periods would be about 15 feet.

Dam Raise Scenarios

Following is a description of the three dam raise scenarios included in the 1999 appraisal report (Reclamation 1999) and two expanded low-level scenarios.

Low-Level Raise – 6.5 Feet

Major components and accomplishments and costs (including increased water supply reliability, implementation costs, and unit costs) for the low-level raise (6.5 feet) are described in this section.

Major Components

The 6.5-foot Low-Level Raise scenario consists of a structural dam raise of 6.5 feet with a new enlarged crest elevation at 1,084 feet. This scenario would have a new top of joint-use storage space at elevation 1,075.5, and result in an additional 8.5 feet of water in the reservoir. The total capacity of this new reservoir would be 4.84 MAF, which is an increase of 256,000 acre-feet above the existing available storage. At full pool storage, the reservoir would cover about 30,700 acres, which is an increase of about 1,100 acres over existing conditions (4 percent increase). Table 3-1 lists major features associated with this dam raise scenario.

Table 3-1. Shasta Dam and Reservoir Enlargement Features

Item	Baseline	Low-Level Raise – 6.5 Feet	Expanded Low-Level Raise – 18.5 Feet	Expanded Low-Level Raise – 30 Feet	Inter-mediate-Level Raise – 102.5 Feet	High-Level Raise – 202.5 Feet
Dam Crest Raise (feet)	NA	6.50	18.50	30.00	102.50	202.50
Dam Crest Elevation (feet)	1,077.50	1,084.00	1,096.00	1,107.50	1,180.00	1,280.00
Full Pool Raise (feet)	NA	8.50	20.50	32.00	104.50	204.50
Full Pool Elevation (feet)	1,067.00	1,075.50	1,087.50	1,099.00	1,171.50	1,271.50
Reservoir Capacity (MAF)	4.55	4.81	5.19	5.57	8.47	13.89
Surface Area @ Full Pool Elevation (acres)	29,600	30,700	32,100	33,700	44,200	60,800
Capacity Increase (MAF)	NA	0.26	0.63	1.02	3.92	9.34

Key:
MAF = million acre-feet
NA = not applicable

The dam raise would be limited to the existing dam crest and appurtenant structures only, with mass concrete placed in blocks on the existing concrete gravity section and precast concrete panels used to retain compacted earthfill placed on wing dam embankment sections. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be extended up to the new crest elevation and the main TCD enclosure would be extended to the new full pool elevation.

Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided. However, with a new full pool elevation of 1,075.5, about seven existing vehicle and railroad bridges would need to be either considerably modified or relocated. Table 3-2 lists estimated infrastructure impacts associated with various increases in full pool. Minor modifications to the Pit River Bridge, which carries Interstate 5 (I-5) and the Water Use Efficiency near Bridge Bay, would be required with this scenario.

The expanded full pool would impact about 45 structures, which would need to be removed or relocated (see Figure 3-2). However, few impacts would occur to reservoir rim ecosystem resources or reservoir-area developed properties.

Table 3-2. Reservoir Infrastructure Impacts and Actions for Elevations 1,070 – 1,280[1]

New Top of Joint-Use Elevation	Impact Remediation Actions
1,072	Relocate UPRR Doney Creek Bridge, UPRR Sacramento River Bridge (2nd Crossing), relocate segment of Bully Hill Road impacted on Squaw Creek Arm
1,073	Relocate portion of Lakeshore Drive impacted by Charlie Creek Bridge
1,074	Relocate McCloud River Bridge and Didallas Creek Bridge; relocate portion of Silverthorn Road impacted on Pit River Arm
1,075	Relocate Second Creek Bridge
1,076	Relocate portion of Lakeshore Drive impacted by Doney Creek Bridge
1,077	Relocate portion of impacted Conflict Point Road (on north side of Salt Creek)
1,078	Build embankment for UPRR at Bridge Bay
1,080	Build embankment for I-5 at Lakeshore; relocate portion of Gilman Road impacted near McCloud Bridge, and portion of Fender Ferry Road impacted near McCloud Bridge
1,090	Relocate UPRR Lakeshore Drive Overcrossing by Charlie Creek
1,091	Relocate Pit River Bridge; relocate UPRR Sacramento River Bridge (2nd Crossing); relocate portion of I-5 impacted by Lakeshore (not necessary with protective dike)
1,094	Relocate UPRR Lakeshore Drive Overcrossing by Doney Creek
1,096	Relocate Wittawaket Creek Bridge and UPRR Sacramento River Bridge, 3rd Crossing
1,097	Relocate UPRR I-5 overpass
1,099	Relocate Squaw Creek Bridge
1,100	Begin to remediate impacts to Silverthorn community (population 1,100 to 1,250)
1,105	Relocate portion of West Side Road impacted at Squaw Creek Bridge
1,106	Reservoir full pool at top of powerhouse at Pit 7 Dam[2]
1,109	Relocate UPRR Sacramento River Bridge, 4th Crossing
1,110	Relocate UPRR Dog Creek Bridge
1,111	Relocate UPRR Salt Creek Bridge
1,114	Relocate Fender Ferry Bridge (Sacramento River near Delta)
1,134	Jones Valley Dike becomes necessary
1,135	Relocate Fender Ferry Bridge (upper Pit River)
1,143	Relocate Tunnel Gulch Viaduct on I-5; relocate UPRR O'Brien Creek Bridge
1,150	Begin to remediate impacts to town of Delta (population 1,150 to 1,190)
1,165	Begin to remediate impacts to town of Pollock (population 1,165 to ~1,220)
1,170	Begin to remediate impacts to town of Lakehead (population 1,170 to ~1,220)
1,172	Relocate UPRR O'Brien Creek Bridge
1,180	Clickapudi Cove Dike becomes necessary
1,230	Bridge Bay and Centimundi dikes become necessary
1,278	Reservoir full pool at crest of Pit 7 Dam[2]

Notes:

[1] This table does not include impacts to specific buildings. Impacted portions of roads, communities, and other infrastructure would be relocated where possible. In cases where relocation is not feasible, facilities may need to be abandoned.

[2] Specific remediation actions at the Pit 7 Dam have not yet been determined. The elevation at which the dam would likely need to be abandoned is between elevation 1,106 (powerhouse yard floor) and elevation 1,278 (crest of dam).

Key:
Delta = Sacramento-San Joaquin Delta
I-5 = Interstate 5
UPRR = Union Pacific Railroad

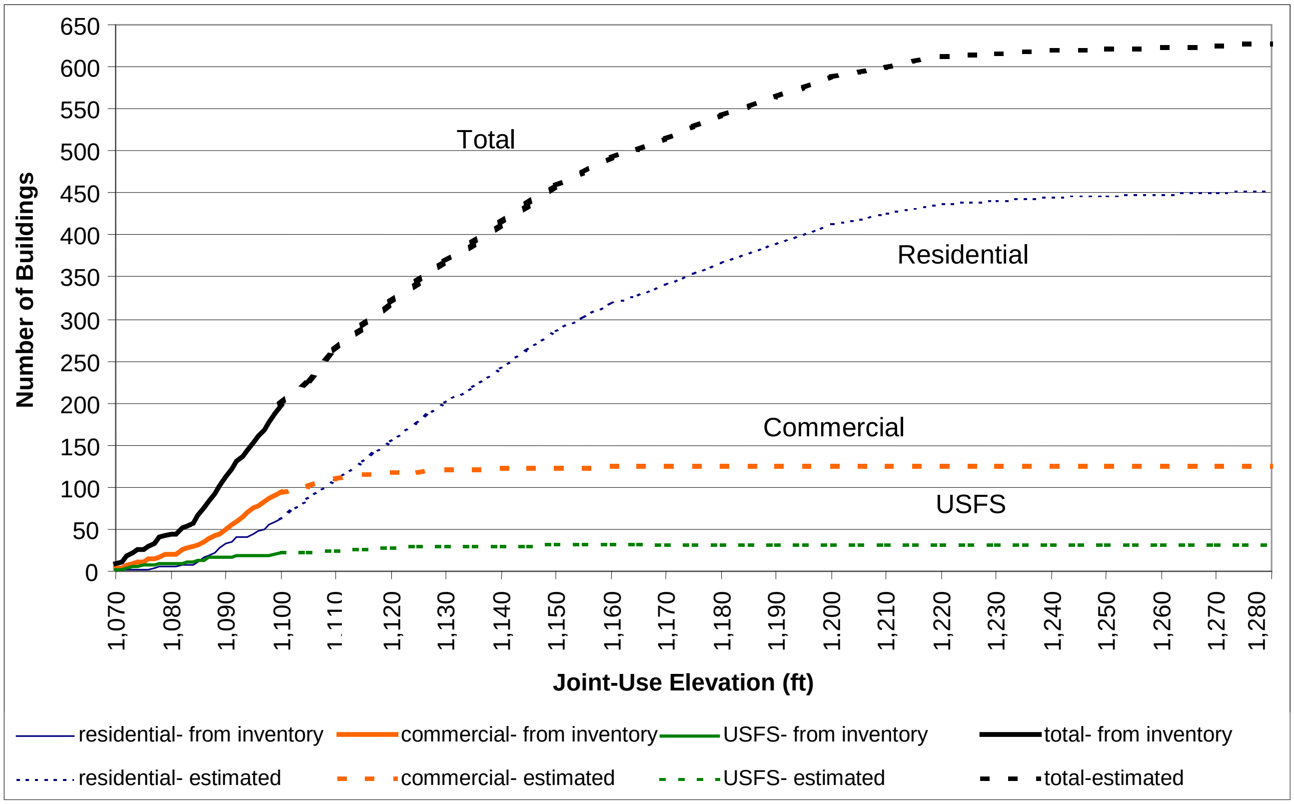

Figure 3-2. Estimated Number of Structures Affected by Increasing the Height of Shasta Dam and Reservoir

Accomplishments and Costs

Although not to the extent of higher raises and associated larger reservoir sizes, this scenario would have the potential to contribute to both primary planning objectives and is also consistent with the goals in the CALFED Programmatic ROD (CALFED 2000a). It could support each of the secondary planning objectives and help increase anadromous fish survival by creation of a small increased cold-water pool. In addition, it could help reduce flood damage along the upper Sacramento River, increase hydropower generation, and slightly increase potential reservoir area recreation opportunities. It would also have minor impacts on the McCloud River and associated issues relating to the State special designation of that waterway.

Increased Water Supply Reliability Water system operation studies for the CVP and SWP were made using the CalSim-II mathematical model for the five dam raise scenarios described in this section. Table 3-3 compares simulated annual CVP and SWP deliveries for average year and dry and critical year conditions, with Banks Pumping Plant capacity at 6,680 cfs, for various Shasta Dam raise scenarios. The table shows the relative increase in reliability of each dam raise scenario to meet future demands. As expected, higher dam raise scenarios have a considerably higher potential to meet future demands.

It should be mentioned that the estimated system deliveries shown in Table 3-3, which were estimated in 2003, differ from that shown in other sections of this appendix and in the main report. This is due to continuing updates in the CalSim-II model. It is important to understand that these differences in system deliveries would not change the fundamental conclusions reached concerning cost efficiencies associated with relative increases of Shasta Dam and Reservoir.

Table 3-3. Estimated CVP/SWP System Deliveries Increase (2003 Estimates)

Dam Raise	Average Year Conditions[1] (TAF per year)	Drought Year Conditions[1] (TAF per year)
Low-Level Raise – 6.5 Feet	48	72
Expanded Low-Level Raise – 18 Feet	71	125
Expanded Low-Level Raise – 30 Feet	110	185
Intermediate-Level Raise – 102.5 Feet	214	425
High-Level Raise – 202.5 Feet	331	703

Note:
[1] Estimated CVP/SWP deliveries differ from other sections of appendix and main report due to update of CalSim-II model used. Differences are relative and do not change the overall conclusions reached.
Key:
CVP = Central Valley Project
SWP = State Water Project
TAF = thousand acre-feet

Preliminary Implementation Costs Preliminary estimates of total first and annual costs for Shasta Dam raise scenarios were developed for relative comparison purposes. Costs were based primarily on updating information contained in Reclamation’s 1999 appraisal report to October 2003 price levels, a 5-5/8 percent interest rate, and a 100-year analysis period. Estimated costs are summarized in Table 3-4.

It should be mentioned that, as with system deliveries shown above, the costs shown here will differ from those shown elsewhere in this appendix and in the main report. This is primarily due to updates in cost estimates and price level changes. However, it is important to note that these changes would not change the fundamental conclusions reached concerning cost efficiencies associated with relative increases of Shasta Dam and Reservoir.

Table 3-4. First and Annual Costs for Dam Raise Options

Dam Raise Options	First Cost @ 2003 Price Levels ($millions)[1]	Annual Costs @ 2003 Price Levels ($millions)[2]
Low-Level Raise	282	19
Expanded Low-Level Raise – 18.5 Feet (without major relocations)	408	28
Expanded Low-Level Raise – 18.5 Feet (with major relocations)	1,060	75
Expanded Low-Level Raise – 30 Feet (block raise)	1,250	89
Expanded Low-Level Raise – 30 Feet (mass raise)	1,330	94
Intermediate-Level Raise – 102.5 Feet	3,890	283
High-Level Raise – 202.5 Feet	5,250	383

Notes:
[1] Most information updated by price levels and interest rates from May 1999 Shasta Dam and Reservoir Enlargement, Appraisal Assessment, by Reclamation. October 2003 price levels.
[2] Construction period of 6 years for lower raise scenarios, and 8 to 10 years for higher raise scenarios. Average annual costs based on 5-5/8 percent over a 100-year project life.

Figure 3-3 shows the estimated first cost for each scenario; two cost estimates were developed for each Expanded Low-Level Raise scenario. The intent of the two estimates was to determine the influence of major cost breaks or jumps resulting from implementing major relocations for the 18.5-foot raise scenario, and additional dam construction costs for the 30-foot raise scenario. Cost estimates for each Expanded Low-Level Raise scenario in the table are based primarily on interpolating costs between the Low-Level and Intermediate-Level raises.

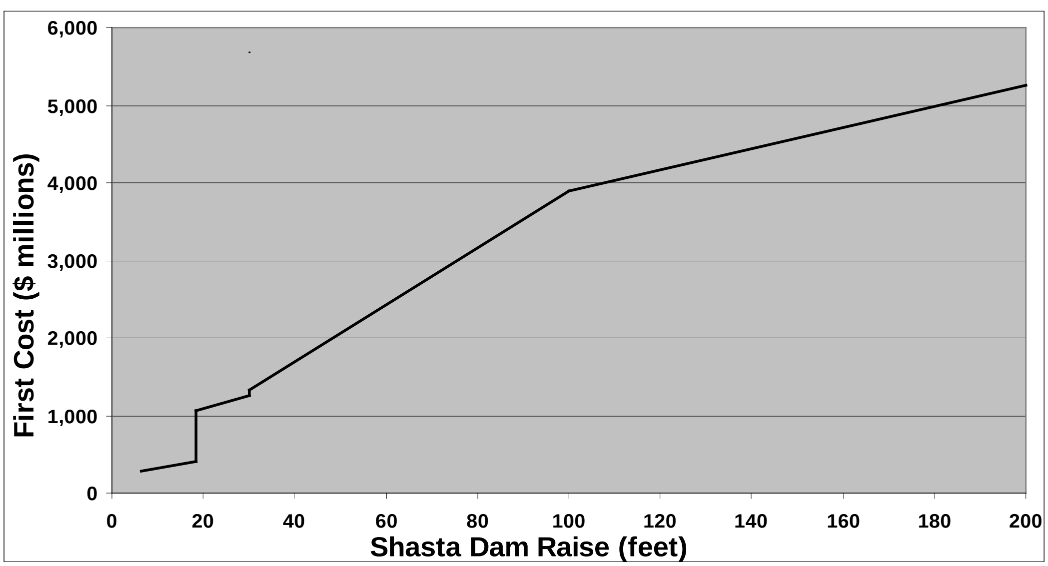

Figure 3-3. Estimated First Cost for Various Shasta Dam Raises at 2003 Price Levels

Unit Costs Table 3-5 summarizes the estimated total storage, increased water supply deliveries, and first and annual costs for each scenario considered. The table also shows the estimated unit cost of water for the various dam raise scenarios, and estimates of unit costs for the two Expanded Low-Level scenarios, including major relocations and dam construction costs at estimated major breakpoints. The total storage unit cost in the table is the estimated cost to develop an acre-foot of new storage. Total storage unit cost is the total first cost divided by the additional storage created by the scenario. The unit cost for increased water supply deliveries is computed using estimates of both average annual and dry and critical year deliveries. Unit cost information from Table 3-5 as a function of new dam crest elevation was used to create the plot in Figure 3-4. The need for major relocations (primarily for I-5 and UPRR facilities) for a dam raise of about 18.5 feet (elevation 1,095) has a dramatic effect on the estimated unit cost for new storage and new water supplies at Shasta. The need to change construction methods for a dam raise of about 30 feet (elevation 1,107.5) has a considerably smaller influence.

Table 3-5. Water Supply Unit Cost Summary (2003 conditions)

Description	Low-Level Raise – 6.5 Feet	Expanded Low-Level Raise – 18.5 Feet		Expanded Low-Level Raise – 30 Feet		Inter-mediate-Level Raise	High-Level Raise
		Without Bridges	With Bridges	Block Raise	Mass Raise		
Added Storage (1,000 acre-feet)	256	634	634	1,020	1,020	3,920	9,340
Increased CVP/SWP Deliveries (1,000 acre-feet per year)							
- Average Annual	48	71	71	110	110	214	331
- Drought Year	72	125	125	185	185	425	703
Unit Cost ($/acre-foot) [1]							
- Total Storage[2]	970	640	1,670	1,230	1,300	990	560
- Increased CVP/SWP Deliveries – Average Annual[3]	410	400	1,050	810	850	1,320	1,160
- Increased CVP/SWP Deliveries – Dry and Critical Year[4]	270	225	600	480	510	670	550

Notes:
[1] First cost divided by increase in total storage.
[2] Annual cost divided by increased average annual deliveries.
[3] Annual cost divided by increased dry and critical year deliveries.

Key:
CVP = Central Valley Project
SWP = State Water Project

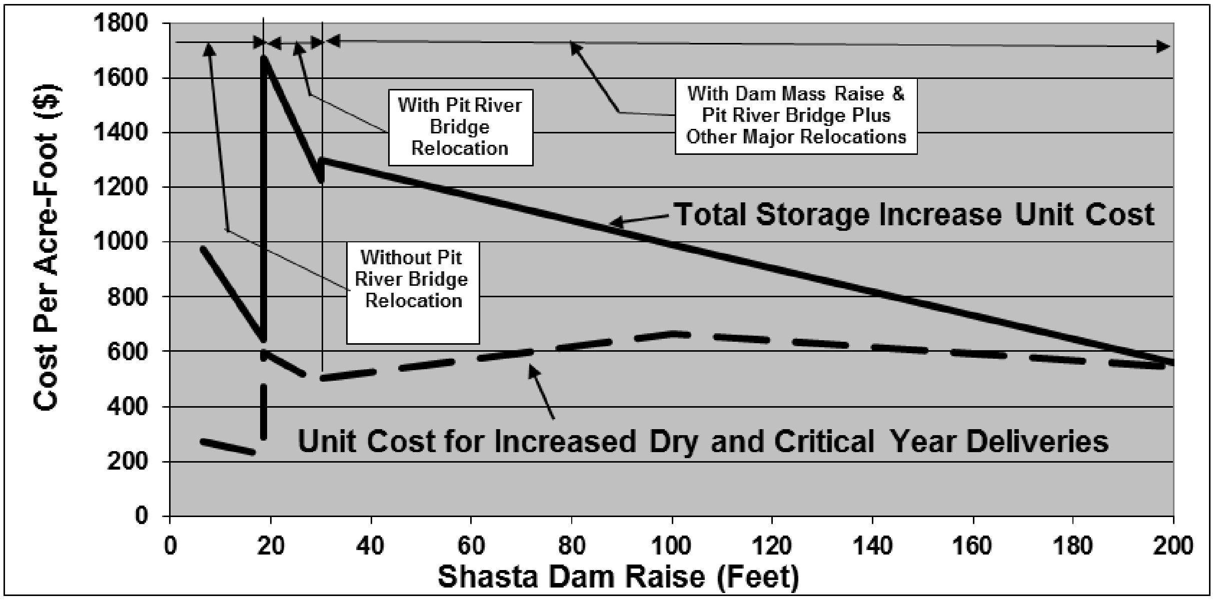

Figure 3-4. Plot of Total Storage and Unit Cost for Increased Dry and Critical Year CVP and SWP Deliveries (2003 price levels) for Various Increases of Shasta Dam Raise

Expanded Low-Level Raise – 18.5 Feet

Major components and accomplishments and costs for the Expanded Low-Level Raise (18.5 feet) are described in this section.

Major Components

This scenario consists of a structural dam raise of 18.5 feet with a new crest at elevation 1,096. The total capacity of this new reservoir would be 5.19 MAF, which is an increase of 634,000 acre-feet above the existing available storage. At full pool storage, the reservoir would cover about 32,100 acres, which is an increase of about 2,500 acres over existing conditions (9 percent).

The dam raise would be limited to the existing dam crest and appurtenant structures only, with mass concrete placed in blocks on the existing concrete gravity section and concrete wing dams constructed on both abutments. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be raised up to the new crest elevation and the main TCD enclosure would be extended to the new full pool elevation.

The 18.5-foot Expanded Low-Level Raise scenario would require a new crest roadway, spillway bridge, elevators, gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only; waterstops and other seepage control measures would be provided.

As can be determined from Table 3-2, with the increased full pool at elevation 1,087.5, an estimated seven bridges in the reservoir area would need to be modified and/or relocated. Pending the results of additional analysis, it appears that this scenario represents the likely greatest dam raise without full relocation of I-5 and the UPRR Pit River Bridge at Bridge Bay. Even at a full pool elevation increase of 20.5 feet, the water surface would encroach to within 4 feet of the low cord of the bridge, which is believed to be the minimum freeboard allowable before full relocation for railroad bridges. To prevent adverse impacts to two bridge piers (Piers 3 and 4) resulting from periodic inundation, the project would include constructing a skirting system around the upper portions of the piers. For clearance for houseboats, a maximum full pool raise would be limited to about 14 feet. However, it is believed that because of the infrequent occurrences of the water surface reaching full pool during high recreation periods, appropriate mitigation features can be included for this scenario.

The expanded full pool area would require about 130 structures (2003 estimate) to be removed or relocated (see Figure 3-2). Relatively minor impacts would occur to reservoir rim ecosystem resources. However, this scenario also includes relocating many reservoir area recreation facilities.

Accomplishments and Costs

This scenario would contribute considerably to both primary planning objectives. It also could support each secondary planning objective. Increasing the full pool storage at Shasta Reservoir by about 634,000 acre-feet by raising the dam 18.5 feet would increase average annual and annual dry and critical year deliveries, based on 2003 CalSim-II modeling assumptions, by about 71,000 and 125,000 acre-feet (67,000 and 133,000 acre-feet in 2006 evaluations), respectively (see Table 3-5). It could also help increase anadromous fish survival by increasing the cold-water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would slightly increase potential reservoir area recreation opportunities. This scenario is generally consistent with the goals and objectives in the 2000 CALFED Programmatic ROD. It would have minor and manageable impacts on the McCloud River and issues relating to the State special designation of that waterway.

As shown in Table 3-4, to accomplish this magnitude of dam raise without major reservoir area relocations, the estimated first cost based on 2003 price levels for this scenario would be about $408 million. The estimated average annual cost would be about $28 million. This would result in a unit cost for the new storage space in Shasta Reservoir of about $640 per acre-foot (Table 3-5). The resulting estimated unit costs for increased average annual and dry and critical year deliveries would be about $400 and $225 per acre-foot, respectively (see Figure 3-4).

Tables 3-4 and 3-5 and Figures 3-3 and 3-4 also show the estimated impact on the first, annual, and unit costs for an 18.5-foot dam raise, including the possible relocation of I-5 and the UPRR Pit River Bridge at Bridge Bay. It is believed that this relocation would be needed for a dam raise greater than about 18.5 feet. With these additional relocations, the first cost would increase to an estimated $1.06 billion. The estimated total unit storage cost would increase to about $1,670 per acre-foot. The estimated unit cost for increased average annual and dry and critical year deliveries would be about $1,050 and $600 per acre-foot, respectively.

Expanded Low-Level Raise – 30 Feet

Major components and accomplishments and costs for the Expanded Low-Level Raise (30 feet) are described in this section.

Major Components

This scenario consists of a structural dam raise of 30 feet with a new crest at elevation 1,107.5 (see Table 3-1). This scenario would have a new top of joint-use (full pool) storage space at elevation 1,099, resulting in an additional 32 feet of water in the reservoir. The total capacity of this new reservoir would be 5.57 MAF, an increase of 1.02 MAF above the existing available storage. At full pool storage, the reservoir would cover about 33,700 acres, which is an increase of about 4,100 acres over existing conditions (14 percent).

This scenario represents the likely greatest dam raise without major modification of the dam mass (concrete overlay on downstream face) and replacement of wing dams, river outlets, and penstocks. The dam raise would be limited to the existing dam crest and appurtenant structures only, with mass concrete placed in blocks on the existing concrete gravity section and concrete wing dams constructed on both abutments. A new spillway crest section would be developed within the raised structure. Control features of the existing TCD would be raised up to the new crest elevation and the main TCD enclosure would be extended to the new full pool elevation.

The 30-foot Expanded Low-Level Raise scenario would require a new crest roadway, spillway bridge, elevators and gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. Although the raised dam crest construction would remain above the new top of joint-use storage, and provide for flood surcharge only, waterstops and other seepage control measures would be provided.

The expanded full pool area would require about 200 structures to be removed or relocated (see Figure 3-2). This scenario would also result in impacts to various major and minor transportation, recreation, hydropower, and other reservoir area facilities. In addition, it would require replacement of the Pit River Bridge at Bridge Bay and 12 other major and minor reservoir area bridges and roadway segments. Also, most recreational facilities would require relocation. Considerable impacts to reservoir rim and tributary stream ecosystem resources would occur.

Accomplishments and Costs

This scenario also would contribute considerably to both primary planning objectives and support each of the secondary planning objectives. Increasing the full pool storage at Shasta Reservoir by over 1 MAF through raising the dam 30 feet would increase the average annual and annual dry and critical year CVP deliveries by an estimated 110,000 and 185,000 acre-feet, respectively (see Table 3-5). It could help increase anadromous fish survival by creating an increased cold-water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would increase potential reservoir area recreation opportunities. This scenario is generally consistent with the goals and objectives in the 2000 CALFED Programmatic ROD. It would, however, have impacts on the lower McCloud River and issues relating to the State of California Species of Special Concern designation in that watershed.

As shown in Table 3-4 and Figure 3-3, the estimated first cost based on 2003 price levels for this scenario would be about $1.25 billion. The estimated average annual cost is $89 million. This would result in a unit cost for the new storage space in Shasta Reservoir of about $1,230 per acre-foot (Table 3-5). Estimated unit costs for increased average annual and dry and critical year deliveries would be about $810 and $480 per acre-foot, respectively.

It is believed that for dam raises greater than about 30 to 50 feet, the existing concrete gravity dam section would need to be raised using a mass concrete overlay as opposed to raising the dam using concrete blocks. Tables 3-4 and 3-5 and Figures 3-3 and 3-4 also show the estimated impact on first, annual, and unit costs for a 30-foot dam raise, including this change in construction method. With the mass concrete overlay raise, the first cost would increase to an estimated $1.33 billion and the estimated total unit storage cost would increase to about $1,300 per acre-foot. The estimated unit cost for increased average annual and dry and critical year deliveries would be about $850 and $510 per acre-foot, respectively.

Intermediate-Level Raise – 102.5 Feet

Major components and accomplishments and costs for the Intermediate-Level Raise (102.5 feet) are described in this section.

Major Components

The Intermediate-Level Raise scenario consists of a structural dam raise of 102.5 feet to a new crest at elevation 1,180 (see Table 3-1). The new top of joint-use storage space would be at elevation 1,171.5. This would allow for storage of an additional 104.5 feet of water in the reservoir above the existing joint-use storage pool elevation. Total capacity of this new reservoir would be 8.47 MAF, or an increase of 3.92 MAF above the existing available storage. At full pool storage, the reservoir would cover about 44,200 acres, which is an increase of about 14,600 acres over existing conditions (49 percent). Figure 3-5 includes the aerial extent of the Intermediate-Level Raise scenario in relationship to other dam raise scenarios being considered.

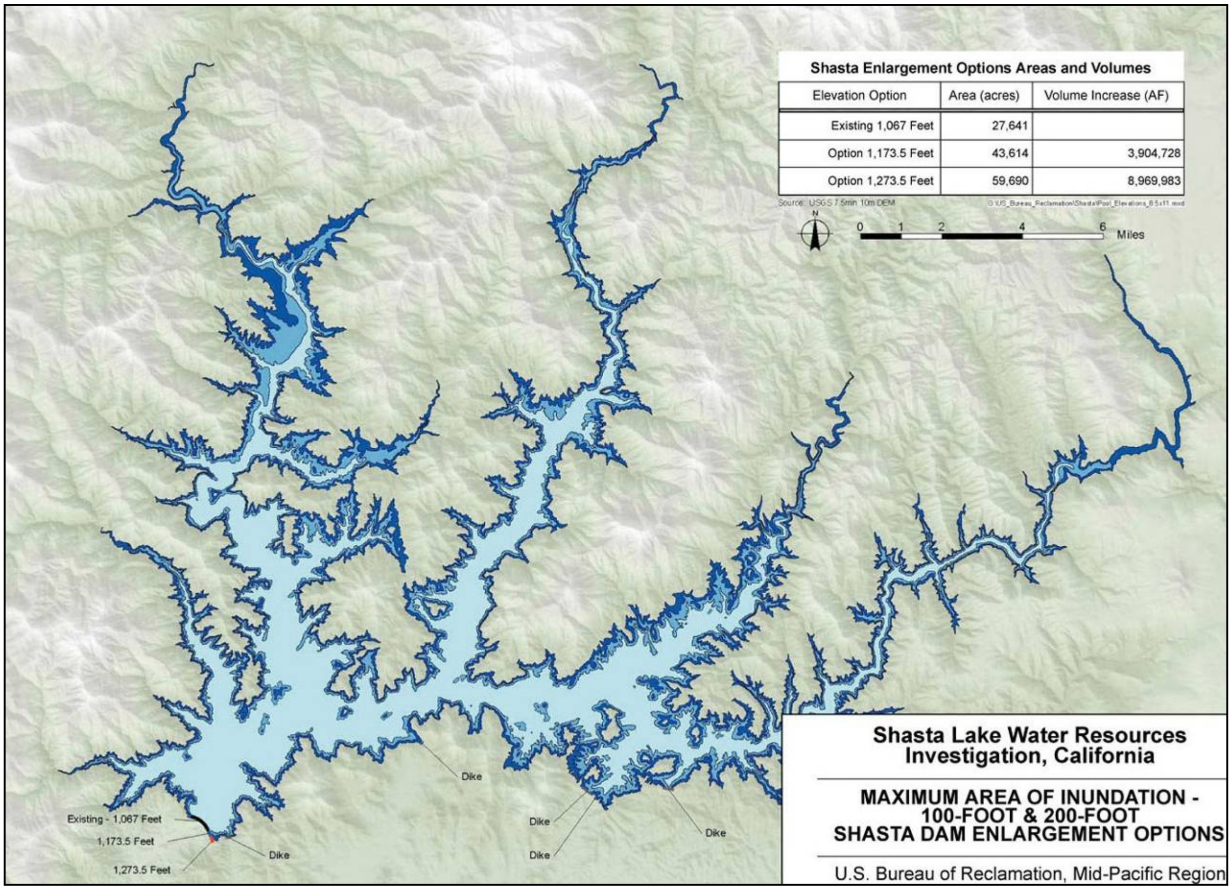

Figure 3-5. Shasta Lake Maximum Area of Inundation for 100-foot and 200-foot Dam Raise Options

The existing concrete gravity dam section would be raised using a mass concrete overlay on the main section of the dam with roller-compacted concrete wing dams constructed on both abutments. The left wing dam would extend approximately 1,380 feet, and the right wing dam would extend approximately 420 feet. The mass concrete overlay on the downstream face of the existing dam in the main section would extend from elevation 1,180 down to the foundation contact at the downstream toe on a 0.7:1 slope. The spillway section would be made thicker to accommodate the gated spillway crest.

This dam raise scenario would require a new crest roadway, spillway bridge, elevators, and a gantry crane, and associated mechanical equipment required for operating the various outlet gates, TCD, and other features. It would also involve constructing two new saddle dikes at Jones Valley and Clickapudi Creek.

The expanded full pool area would require about 520 structures to be removed or relocated (see Figure 3-2). This scenario also would result in impacts to numerous major and minor transportation, recreation, hydropower, and other reservoir area facilities. New power facilities would likely be needed at Shasta Dam, primarily including improvements to the existing penstocks. In addition, most recreational facilities would require relocation. Considerable impacts would occur to historical and cultural resources in the Shasta Lake area. Major impacts would occur to reservoir area and tributary stream ecosystem resources. The Intermediate-Level Raise would also require relocation or abandonment of the Pacific Gas and Electric Company (PG&E) Pit 7 Dam and Powerhouse on the upper Pit River just upstream from Shasta Lake.

It is important to note that in addition to the Pit River Bridge, which would be the single most costly relocation item associated with a dam raise, 20 other bridges cross Shasta Lake or one of its tributaries. A considerable number of bridge relocations would be required with minor increases in the top of joint-use elevation, and all of the main reservoir bridges would need to be relocated with a top of joint-use raise of about 73 feet. However, with greater increases in top of joint-use elevations, major railroad and/or roadway system relocation (UPRR and I-5) also would be required.

Accomplishments and Costs

This scenario would considerably contribute to both primary planning objectives and also support each of the secondary planning objectives. Increasing the full pool storage at Shasta Reservoir by 3.9 MAF by raising Shasta Dam 102.5 feet would increase the estimated average annual and dry and critical year CVP deliveries by an estimated 214,000 and 425,000 acre-feet, respectively (see Table 3-5). It could help increase anadromous fish survival by creating a small increased cold-water pool. In addition, it could help reduce flood damages along the upper Sacramento River, and increase hydropower generation. It would result in a considerable increase in potential reservoir area recreation opportunities. However, it would have major impacts on the McCloud River and issues relating to the State special designation of that waterway.

Because of the considerable increase in storage in Shasta Reservoir for this scenario, and resulting influence on residual available water resources in the upper watershed, planning for other potential water resources projects would be likely influenced measurably. Also, because this scenario requires most of the infrastructure within the reservoir area to be relocated, considerable disruption would occur to local and interstate roadway and railroad transportation, recreation, and related facilities in the Shasta Lake region.

As shown in Table 3-4 and Figure 3-3, the estimated first cost (2003 price levels) for this scenario is about $3.9 billion with an estimated average annual cost of about $283 million. The estimated unit cost for the new storage space in Shasta Lake would be about $990 per acre-foot. The resulting unit cost for the increased average annual and dry and critical year water supply deliveries would be about $1,320 and $670 per acre-foot, respectively (Table 3-5).

High-Level Raise – 202.5 Feet

Major components and accomplishments and costs for the High-Level Raise (202.5 feet) are described in this section.

Major Components

The High-Level Raise scenario consists of a structural dam raise of 202.5 feet to a new crest at elevation 1,280 (see Table 3-1). The new top of joint-use storage space would be at elevation 1,271.5. This would allow storage of an additional 204.5 feet of water in the reservoir. The total capacity of this new reservoir would be 13.89 MAF, an increase of 9.34 MAF above the existing available storage. This dam raise represents the highest practical raise of Shasta Dam. Enlargements beyond this point would begin to experience considerable geological foundation problems. At least one upstream PG&E dam and powerhouse would be relocated with the high level raise – Pit 7 Dam and powerhouse on the upper Pit River. At full pool storage, the reservoir would cover about 60,800 acres, which is an increase of about 31,200 acres over existing conditions (105 percent). Figure 3-5 shows the aerial extent of the High-Level Raise scenario in relationship to other dam raise scenarios being considered.

The existing concrete gravity dam section would be raised using a mass concrete overlay on the existing dam crest and downstream face. The upstream face within the curved nonoverflow sections would extend vertically to the new dam crest at elevation 1,280, and the downstream face would have a 0.7:1 slope to the downstream toe. The dam crest would be completed with a crest cantilever for the roadway surface, sidewalks, and parapet walls. Existing elevator shafts would be extended to the new dam crest, and new elevator towers would be provided. The spillway section would require a thicker section to accommodate the gated spillway crest.

The new dam crest would include a crest roadway and spillway bridge, passenger and freight elevators, and three gantry cranes. This option would require constructing four saddle dikes to close off the gaps between mountain peaks in the upper watershed. A new powerplant and associated switchyard facilities would be included on the left abutment. The existing powerplant would continue to be operated within its operation range. The existing penstocks on the right abutment would be upgraded.

The expanded full pool area would require nearly 630 structures to be removed or relocated. As with the Intermediate-Level Raise scenario, this scenario would require replacement of major infrastructure associated with Shasta Dam and Reservoir.

Considerable impacts would occur to historical and cultural resources in the Shasta Lake area. Major impacts would occur to reservoir area and tributary stream ecosystem resources. This scenario would have major and likely irreversible impacts to the McCloud River and issues relating to the State special designation of that waterway.

Accomplishments and Costs

This High-Level Raise scenario would contribute considerably to both primary planning objectives and support each of the secondary planning objectives. Increasing the full pool storage at Shasta Reservoir by 9.1 MAF by raising Shasta Dam 202.5 feet would increase the estimated average annual and dry and critical year CVP deliveries by an estimated 330,000 and over 700,000 acre-feet, respectively (see Table 3-5). It would considerably increase anadromous fish survival by creating a very large increased cold-water pool. In addition, because of the considerable increase in total space in Shasta Reservoir capable of capturing considerably more peak flood flows, this scenario could help resolve many existing flood problems along the upper Sacramento River. It would result in major increases in hydropower generation. It also would result in a substantial increase in water-oriented recreation in Shasta Lake by more than doubling the lake surface area at full pool elevation.

Because of the considerable increase in storage in Shasta Reservoir for this scenario, and resulting influence on residual available water runoff from the upper Sacramento River watershed, planning for other potential water resources projects in the Central Valley very likely would be influenced measurably. Also, because the scenario would require most of the infrastructure within the reservoir area to be relocated, considerable disruption would occur to local and interstate roadway and railroad transportation, recreation, and related actions in the Shasta Lake region.

The estimated first cost for this scenario (2003 price levels) is about $5.2 billion with an estimated average annual cost of about $383 million (see Table 3-4). The estimated unit cost for new storage space in Shasta Lake would be about $560 per acre-foot (Table 3-5). The resulting unit cost for the average annual and dry and critical year water supply deliveries would be about $1,160 and $550 per acre-foot, respectively (Table 3-5).

Initial Screening

The five dam raise scenarios were compared to identify the scenarios that should be considered in more detail and included in concept plans. Table 3-6 is a summary comparison and screening of each scenario. As shown in the table, three Shasta Dam enlargement scenarios were identified for development into concept plans: the Low-Level Raise – 6.5-foot scenario, Expanded Low-Level Raise – 18.5-Foot scenario, and High-Level Raise – 202.5-foot scenario. The Expanded Low-Level Raise – 30-foot, Intermediate-Raise, and all other Shasta Dam and Reservoir enlargement scenarios were eliminated from further consideration. Following is a summary of each scenario.

Table 3-6. Summary Comparison of Shasta Dam Raise Scenarios (2003 Analysis)

Description	Low-Level Raise (6.5 feet)	Expanded Low-Level Raise (18.5 feet)	Expanded Low-Level Raise (30 feet)	Intermediate-Level Raise (102.5 feet)	High-Level Raise (202.5 feet)
Major Features					
Dam Crest Raise (feet)	6.5	18.5	30	102.5	202.5
Full Pool Raise (feet)	8.5	20.5	32	104.5	204.5
Capacity Increase (million	0.26	0.63	1.02	3.92	9.34
Surface Area Increase (%)	4	8	14	49	105
Water Reliability Accomplishments					
Dry and Critical Year Increased Deliveries	72	125	185	425	703
CVP Yield Replacement (%)[1]	13	20	31	77	100
Cost (2003 Price Levels)					
First Cost ($ millions)	282	408	1,250	3,890	5,250
Annual Cost ($ millions)	19	28	89	283	383
Unit Cost ($/AF)[2]	270	225	480	670	550
Major Advantages	• Low unit cost. • No major relocations. • Consistent with 2000 CALFED Programmatic ROD. • Can contribute to both primary planning objectives. • Potential to provide about 5 and 14 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins. • Low impacts in reservoir rim area.	• Low unit cost. • No major relocations. • Consistent with goals of 2000 CALFED Programmatic ROD. • Can contribute to both primary planning objectives. • Potential to provide up to about 7 and 20 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can contribute to both primary planning objectives. • Potential to provide up to about 11 and 31 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can contribute to both primary planning objectives. • Can contribute considerably to increased recreation, hydropower, and flood control secondary objectives. • Potential to provide about 27 and 77 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins.	• Can considerably contribute to both primary planning objectives. • Can contribute considerably to increased recreation, hydropower, and flood control secondary objectives. • Potential to provide about 45 and 100 percent of projected 2020 drought and average year shortages, respectively, in the Sacramento and San Joaquin River basins. • Likely lowest-cost project capable of resolving current and future water supply shortages.

Table 3-6. Summary Comparison of Shasta Dam Raise Scenarios (2003 Analysis) (contd.)

Description	Low-Level Raise (6.5 feet)	Expanded Low-Level Raise (18.5 feet)	Expanded Low-Level Raise (30 feet)	Intermediate-Level Raise (102.5 feet)	High-Level Raise (202.5 feet)
Major Disadvantages	• Relatively low potential to meet primary objectives.	• Marginal potential to meet primary objectives. • Moderate reservoir rim impacts.	• Very high unit cost. • Requires major reservoir area relocations.	• High unit water cost. • Requires major reservoir area relocations. • High reservoir area impacts.	• High unit water cost. • Requires major reservoir area relocations. • Very high reservoir area impacts.
Status	• **Retained** for further development – low unit water cost.	• **Retained** for further development – considerable accomplishments for planning objectives and low unit water cost.	• **Deleted** from further consideration – major relocations and high unit water cost.	• **Deleted** from further consideration – major reservoir impacts and high unit water cost.	• **Retained** for further consideration – high potential to meet current and future water shortages.

Notes:
[1] Percent replacement of CVPIA water reallocation.
[2] Unit cost for increased dry and critical year deliveries.

Key:
AF = acre-feet
CVP = Central Valley Project
ROD = Record of Decision

- **Low-Level Raise – 6.5 Feet –** On the basis of an estimated unit cost per an increase in dry and critical year deliveries of $270 per acre-foot, this scenario would be one of the most efficient of the five considered. Primarily due to (1) the relatively low cost for additional dry and critical year water supplies, (2) high reliability of accomplishing its identified benefits, (3) low overall impact to ecosystem and related resources, (4) ability to combine with other measures, and (5) consistency with goals in the 2000 CALFED Programmatic ROD, this scenario was retained for more detailed analysis as part of the concept plans.

- **Expanded Low-Level Raise – 18.5 Feet –** On the basis of an estimated unit cost per increase in dry and critical year deliveries as low as $225 per acre-foot, this scenario also would be one of the most efficient of the five considered. This option was retained for more detailed analysis, primarily due to (1) the potential for additional dry and critical year water supplies and high potential to influence average year water supply reliability, (2) low implementation cost and water supply reliability cost, (3) relatively low overall impact to ecosystem and related resources, and (4) consistency with the goals of the 2000 CALFED Programmatic ROD.

- **Expanded Low-Level Raise – 30 Feet –** On the basis of an estimated high unit cost for increased system deliveries, this scenario would result in relatively low economic efficiency compared with the 6.5-foot and 18.5-foot scenarios. Primarily due to considerably higher implementation costs relative to accomplishments, this scenario was deleted from further consideration.

- **Intermediate-Level Raise – 102.5 Feet –** On the basis of an estimated high unit cost for increased system deliveries, this scenario also would result in low economic efficiency compared with the other dam raise scenarios. Primarily due to considerably higher implementation costs and unit costs for water supply reliability relative to overall accomplishments, this scenario was deleted from further consideration.

- **High-Level Raise – 202.5 Feet –** On the basis of an estimated high unit cost for increased system deliveries, this scenario would result in relatively low economic efficiency. However, no other known single surface water storage project or combination of surface water projects in the Central Valley of California is as capable of considerably addressing the projected future water shortages with comparable unit water costs as the High-Level Raise scenario. This scenario could provide nearly half the total expected 2020 water shortages of the CVP and SWP. Also, it could almost completely fulfill the water supply replacement objectives of the CVPIA. It would, however, result in major resources impacts in the reservoir area. Primarily because unit costs for new water storage and for increased reliability for average annual deliveries would be highly competitive at the magnitude of potential developed supplies compared to other surface water storage projects considered by CALFED, this scenario was carried forward for inclusion in a concept plan.

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Chapter 4
Concept Plans

During the Initial Alternatives Phase, a set of plans that were conceptual in scope (concept plans) was formulated from the retained management measures presented in Chapter 2. Because there is a vast array of potential measure combinations and sizes, the strategy was not to develop an exhaustive list of concept plans or to optimize outputs. Rather, the purpose of this phase of the formulation process was to (1) explore an array of different strategies to address the primary planning objectives, constraints, considerations, and criteria, and (2) identify concepts that warranted further development in the comprehensive plans phase.

The formulation strategy was to develop an array of concept plans representative of the range of potential actions to address objectives of the SLWRI. First, two sets of plans were developed that focused on either anadromous fish survival (AFS) or water supply reliability (WSR) as the single primary planning objective. Three AFS plans and four WSR plans were developed. Although the AFS and WSR plans focused on single planning objectives, each generally contributes to both primary planning objectives. In the three AFS concept plans, for example, emphasis was placed on the combinations of measures that could best address the fish survival goals while considering incidental benefits to WSR, if possible. Second, five concept plans were developed that included measures to address both primary and, to a lesser degree, secondary planning objectives. These are termed combined objective (CO) plans.

This chapter is organized into three sections, beginning with a discussion of the measures contained in the concept plans, including a discussion of features that are common to some or all of the plans. The AFS, WSR, and CO concept plans then are discussed individually. Last, the concept plans are compared to determine the relative scope of comprehensive alternative plans.

Overview of Concept Plan Features

Table 4-1 summarizes how the retained measures were combined to form concept plans that focus on anadromous fish, water supply reliability, or COs. The concept plans and their unique features are discussed individually in the remaining sections of this chapter. Calculated values referenced in this chapter are from the June 2004 *Initial Alternatives Information Report* (Reclamation 2004a). Raises of 6.5 feet and 18.5 feet were evaluated based on enlarged storage capacities of 290,000 acre-feet and 636,000 acre-feet, respectively.

Subsequent evaluations determined that the increases in capacity for these raises are 256,000 acre-feet and 634,000 acre-feet, respectively. The current comprehensive plans discussed in Chapter 5 reflect these changes.

Table 4-1. Summary of Concept Plan Features

Concept Plan	Features												
	Dam Raise	Primary Planning Objective Focus							Secondary Planning Objectives Addressed [4]				
		Water Supply Reliability [2]			Anadromous Fish Survival				Environmental Restoration			Flood Control and Hydropower	
	Raise Shasta Dam[1] (feet)	Increase Conservation Storage	Perform Conjunctive Water Management[3]	Reoperate Shasta Dam	Modify TCD	Replenish Spawning Gravel	Enlarge Shasta Lake Cold-Water Pool	Increase Minimum Flows[3]	Restore Shoreline Aquatic Habitat	Restore Tributary Aquatic Habitat	Restore Riparian Habitat	Modify Flood Control Operations and Implement Shasta Public Safety,[3] Features	Modify Hydropower Facilities
AFS-1	6.5	*		Changes to water supply operations and modification of the TCD would likely be included, to some extent, in any alternative that includes raising Shasta Dam.			X					Changes to flood control operations at Shasta Dam, Public Safety,[3] and hydropower facilities would likely be part of any alternative that includes physically modifying Shasta Dam.	
AFS-2	6.5	*					*	X					
AFS-3	6.5	*				X	*	X					
WSR-1	6.5	X					*						
WSR-2	18.5	X					*						
WSR-3	202.5	X					*						
WSR-4	18.5	X	X				*						
CO-1	6.5	X				X	X						
CO-2	18.5	X				X	X						
CO-3	18.5	X				X	X	X					
CO-4	6.5	X	X			X	X		X	X	X		
CO-5	18.5	X	X			X	X		X	X	X		

Notes:

[1] Raising Shasta Dam provides both water supply and temperature benefits, regardless of how the additional storage is exercised. While the AFS measures focus on use of the additional space for anadromous fish survival, they also provide significant water supply benefits. Similarly, the WSR measures focus on water supply reliability but the reservoir enlargements also provide coincidental benefits to anadromous fish.

[2] All concept plans will include attention to water demand reduction.

[3] These measures were used for evaluation because they were retained at the time of plan formulation. However, they have since been removed from consideration.

[4] Water quality and recreation were not used as evaluation features because they were not retained as a secondary objective at the time concept plans were formulated.

Key:
* Coincidental benefit, although not a primary focus of the concept plan
AFS= anadromous fish survival
CO = combined objectives
TCD = temperature control device
WSR = water supply reliability
X = Primary focus of concept plan

Many of the concept plans share common physical features related to raising Shasta Dam. These include the physical or construction features of dam enlargement, and reservoir area relocations and other impacts.

Each of the concept plans includes enlarging Shasta Dam and Reservoir by 6.5 feet, 18.5 feet, or 202.5 feet. Table 4-2 summarizes various changes in Shasta Dam and Lake for the three dam raises.

Table 4-2. Shasta Dam and Lake Changes – Dam Raise Scenarios

Item	Existing	6.5-Foot Raise	18.5-Foot Raise	202.5-Foot Raise
Shasta Dam				
Type	Concrete Gravity	Concrete Gravity	Concrete Gravity	Concrete Gravity
Construction Means	-	Block Raise (crest)	Block Raise (crest)	Mass Raise (overlay)
Crest Elevation[1]	1,077.5	1,084.0	1,096.0	1,280.0
Dam Crest Length[1]	3,460	3,660	3,770	4,930
Dam Crest Width[1]	30	30	30	30
Shasta Lake				
Elevation Change				
Increase in Full Pool[1]	-	8.5	20.5	204.5
Elevation of Full Pool[1]	1,067.0	1,075.5	1,087.5	1,271.5
Elevation Minimum Operating Pool[1]	840	840	840	840
Capacity (1,000 acre-feet)				
Capacity Increase	-	290[2]	636[2]	9,338
Total at Full Pool[3]	4,552	4,842[2]	5,188	13,890
Minimum Operating Pool	590	590 / 880[4]	590	590
Surface Area Increase (acres)	-	1,100	2,500	31,200

Notes:

[1] All elevations are in feet above mean sea level.

[2] Subsequent evaluations refined the storage capacity increase with a 6.5-foot raise and with an 18.5-foot raise to 256,000 acre-feet and 634,000 acre-feet, respectively. Total capacity for an 18.5-foot raise has been refined to 5,190,000 acre-feet.

[3] Increase in full pool elevation is greater than the magnitude of the dam raise, largely due to the increased efficiency of the steel radial spillway gates that would replace the existing drum gates.

[4] Concept Plan AFS-1 includes increasing the minimum operating pool to 880,000 acre-feet. All other plans assume an existing minimum operating pool of 590,000 acre-feet.

Plans Focused on Anadromous Fish Survival

Three concept plans were formulated from the management measures retained to address the primary planning objective of anadromous fish survival. The main focus of these concept plans is on anadromous fish survival in the upper Sacramento River, but each contributes somewhat to water supply reliability. While numerous possible combinations of the type and size of the measures make up these concept plans, those shown in Table 4-1 and described below are believed to be reasonably representative of the range of potential actions.

Each of the three AFS concept plans includes raising Shasta Dam 6.5 feet, which would raise the full pool level by 8.5 feet and enlarge the reservoir by 290,000 acre-feet. Although larger dam raises could produce greater benefits to fisheries, the goal at this stage in plan formulation was to provide a common baseline from which the relative performance of the three AFS concept plans could be compared. The primary difference between the three AFS concept plans is in how the additional storage gained by the raise would be used to benefit anadromous fish. AFS-1 focuses the additional storage on regulating water temperature in the upper Sacramento River, while AFS-2 and AFS-3 focus the additional storage on regulating flows in the upper Sacramento River. AFS-3 also adds an additional increment, fish habitat restoration on the upper Sacramento River.

AFS-1– Increase Cold-Water Assets with Shasta Operating Pool Raise (6.5 Feet)

AFS-1 focuses on the primary planning objective of anadromous fish survival by raising Shasta Dam 6.5 feet to enlarge the pool of cold water in Shasta Lake. Major plan components include (1) raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the cold-water pool and regulating water temperature in the upper Sacramento River and (2) increasing the size of the minimum operating pool to 880,000 acre-feet.

Both of the major plan components focus on increasing the volume of cold water in Shasta Lake available for regulating water temperature on the upper Sacramento River. AFS-1 would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 MAF. The existing TCD would be extended and potentially modified. In addition, the minimum end-of-October carryover storage target would be increased from 1.9 MAF to about 2.2 MAF, increasing the minimum operating pool to 880,000 acre-feet. This would allow additional cold water to be stored for use the following year. No changes would be made to the existing seasonal temperature targets for anadromous fish on the upper Sacramento River, but the ability to meet these targets would be improved.

For this plan, major relocations include modifying the Pit River Bridge, replacing 7 other bridges, relocating 45 structures, and inundating numerous small segments of existing paved and nonpaved roads. About 20 buildings associated with marinas or resorts would be affected directly, and about 25 other buildings associated with ancillary facilities could be affected indirectly because of their proximity to the new water surface at full pool.

Major benefits of AFS-1 include the following:

- **Anadromous Fish Survival –** Water temperature is one of the most important factors in achieving recovery goals for anadromous fish in the Sacramento River. AFS-1 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperature in the upper Sacramento River, primarily in dry and critical years. This would be accomplished by raising Shasta Dam by 6.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBDD, and can have an extended influence on river temperatures farther downstream. Hence, the most significant benefits to anadromous fish would occur upstream from Red Bluff, but some degree of benefit could be realized as far downstream as the Delta.

  Relationships between anadromous fish mortality and environmental conditions (including water temperature) are very complex. Recent significant strides have been made, however, to try and assess these relationships and resulting influences on increases or decreases in fish populations. For this study, the SALMOD computer model was used to simulate the dynamics of freshwater salmonid populations in the upper Sacramento River. The model's premise is that egg and fish mortality are directly related to spatially and temporally variable micro- and macrohabitat limitations, which themselves are related to the timing and amount of streamflow and other meteorological variables. Information on this model and its application to the SLWRI is presented in the Modeling Appendix. On the basis of this model assessment, it is estimated that AFS-1 could significantly contribute to an average annual increase (reduction in mortality) of salmon. For higher dam raise scenarios with corresponding increases in the minimum operating pool, the benefit to salmon would be proportionally greater.

- **Water Supply Reliability –** AFS-1 would only incidentally contribute to increasing the water supply reliability of the CVP and SWP systems.

- **Other Benefits –** Although the focus of this concept plan was on benefiting anadromous fish in the upper Sacramento River by increasing the cold-water pool in Shasta Lake, minor secondary benefits would occur. The higher water surface in the reservoir would result in a net increase in power generation. The ability to manage floods would not increase significantly. AFS-1 does not include any specific measures to address the secondary planning objective of environmental restoration. Water-oriented recreation at Shasta Lake, and the services it supports, are very important to the economic health and well-being of the community of Redding and surrounding area. AFS-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

The most significant benefit of AFS-1 is the significant increase in anadromous fish population. The plan would not provide significant benefits to water supply reliability, although it would provide incidental increases in hydropower. Consequently, all initial costs for this plan would be allocated to anadromous fish survival.

AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 Feet)

AFS-2 focuses on the primary planning objective of anadromous fish survival by increasing minimum seasonal flows in the upper Sacramento River from the current 3,250 cfs to about 4,200 cfs. The primary component of AFS-2 includes raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run salmon on the upper Sacramento River.

Additional storage created by raising the dam would be focused on increasing the minimum flow target for winter-run Chinook salmon on the upper Sacramento River, consistent with the goals of the January 2001 *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001). Similar to AFS-1, this concept plan would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 MAF, and extend the existing TCD to achieve efficient use of the expanded reservoir. AFS-2 differs from AFS-1 in that the additional storage would be used to increase minimum flows, rather than temperature, and no changes would be made to the carryover target volume or minimum operating pool.

For this concept plan, the additional storage would allow the minimum flow target in the upper Sacramento River to be increased from 3,250 cfs to 4,200 cfs, without adversely impacting water supply deliveries to the CVP. Although 4,200 cfs does not represent flows that produce optimal spawning conditions in the river (closer to 5,000 cfs), it is believed to represent a possible balance between the various beneficial uses of the reservoir.

The benefits of AFS-2 are as follows:

- **Anadromous Fish Survival –** In addition to temperature, river flow is an important factor influencing anadromous fish survival. Flows in the upper Sacramento River are highly influenced by releases from Shasta Dam, particularly during dry years. Higher instream flows would provide access to additional spawning and rearing habitat sites, extend the area of suitable habitat farther downstream, and generally improve aquatic and riparian habitat conditions along the river. Further, over 80 percent of the total (combined) population of spring-run, late-fall-run, and endangered winter-run Chinook salmon spawn between Keswick Dam and Battle Creek. AFS-2 would use the additional 290,000 acre-feet of storage in Shasta to increase minimum flows in this reach of the upper Sacramento River between October 1 and April 30. Benefits would occur primarily during drier years, when flows often fall to the current minimum flow of 3,250 cfs. For example, the average daily outflow from Keswick fell below 4,200 cfs on about 175 days between 1998 and 2004 (period of current operating rules). It should be noted that this figure represents flows averaged over 24-hour periods, and does not reflect hourly fluctuations or every day that flows fell below 4,200 cfs (or the duration of these occurrences).

  A preliminary assessment was conducted, using an existing hydraulic model of the upper Sacramento River, to estimate the increase in available spawning habitat that would occur if flows increased from 3,250 cfs to 4,200 cfs. Although the preliminary assessment has limitations, it provides a means for comparing the relative performance of the concept plans. On the basis of this assessment, it is estimated that AFS-2 could decrease the amount of spawning area between Keswick and Battle Creek that normally becomes dewatered during low flow years by about 170 acres.

  Although the focus of AFS-2 is on increasing minimum flows, raising Shasta Dam also increases the available cold-water pool and allows operators greater flexibility in regulating water temperature in the upper Sacramento River. Based on preliminary analyses, improved temperature conditions under AFS-2 would result in an estimated average annual increase of the salmon population.

- **Water Supply Reliability –** As mentioned previously, using the additional storage to increase minimum flows would result in little or no increase in water supply reliability to the CVP. However, AFS-2 would incidentally contribute to increasing average and dry period water supply reliability to the SWP system. This increase corresponds to about 20,000 acre-feet during critical years.

- **Other Benefits –** A preliminary assessment indicated that the higher water surface in the reservoir would result in a net increase in power generation. Flood control operations at Shasta Dam and Reservoir would continue as under existing conditions. AFS-2 does not include any specific measures to address the secondary planning objective of environmental restoration. However, increasing minimum flows would provide incidental benefits to riparian habitat along the upper Sacramento River. AFS-2 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described for AFS-1. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

AFS-3 – Increase Minimum Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 Feet)

AFS-3 addresses the primary planning objective of anadromous fish survival through a dual focus on (1) instream habitat restoration and (2) increasing minimum seasonal flows on the upper Sacramento River by enlarging Shasta Dam and Reservoir, similar to AFS-2. Major plan components include (1) raising Shasta Dam by 6.5 feet for the primary purpose of enlarging the volume of water available to meet minimum flows for winter-run Chinook salmon on the upper Sacramento River and (2) acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to restore about 150 acres of aquatic and floodplain habitat.

These components are focused on increasing the quality and quantity of spawning habitat on the upper Sacramento River. Similar to AFS-2, minimum spring flows for winter-run Chinook salmon would increase from 3,250 cfs to 4,200 cfs; the capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 MAF; and the existing TCD would be extended to achieve efficient use of the expanded reservoir.

AFS-3 differs from AFS-2 in that an additional increment of instream habitat would be provided by gravel mine restoration along the upper Sacramento River. For the purpose of this initial evaluation, suitable areas totaling 150 acres would be chosen from one or more abandoned gravel mines (see potential sites in Figure 4-1).

Restoration would involve filling deep pits, recontouring the stream channel and floodplain to mimic more natural topography, and reconnecting the reclaimed area to the Sacramento River. Side channels and other features would be created to encourage spawning and rearing, and restored floodplain lands would be revegetated using native riparian plants.

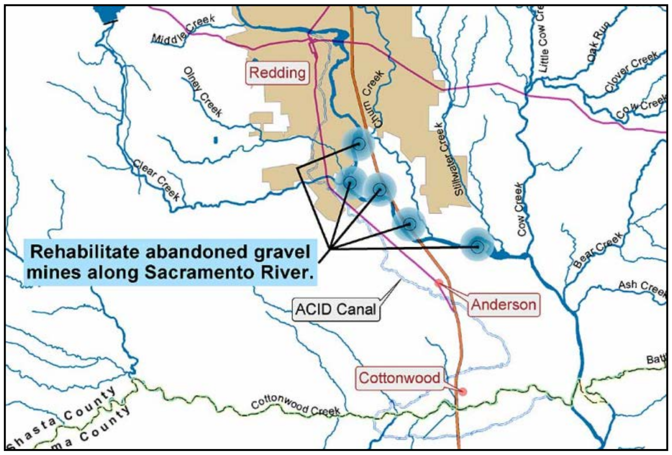

Figure 4-1. Potential Locations Along Sacramento River Where Abandoned Gravel Mines Could Be Considered for Restoration

The primary benefits of AFS-3 include the following:

- **Anadromous Fish Survival –** As described previously, instream flows and the availability of suitable aquatic habitat in the reach between Keswick Dam and Battle Creek are particularly influential on the survival of anadromous fish. AFS-3 would support the primary planning objective of anadromous fish survival by increasing minimum flows from October 1 through April 30 and restoring 150 acres of aquatic and floodplain habitat at one or more inactive gravel mines on the upper Sacramento River. Together, it is estimated that the minimum flow increase and habitat restoration would add approximately 320 acres (restored gravel mines at 150 acres and increased flows at 170 acres) of potential spawning habitat to the upper Sacramento River between Keswick and Battle Creek.

- **Water Supply Reliability –** AFS-3 would incidentally contribute to increasing average and dry period water supply reliability to the SWP system. This increase corresponds to about 20,000 acre-feet during critical years.

- **Other Benefits –** The higher water surface elevations in the reservoir would result in a net increase in power generation of about 32 gigawatt-hours (GWh) per year. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. AFS-3 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that of AFS-1 and AFS-2. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

Plans Focused on Water Supply Reliability

Four concept plans were formulated from the management measures retained to address the primary planning objective of increasing water supply reliability. Although each WSR concept plan contributes somewhat to both primary planning objectives, these four plans focus on the objective of increased water supply reliability. As with the previous set of plans that focus on anadromous fish survival, numerous potential measure combinations and sizes exist. The magnitude of enlarging Shasta Dam was important when developing the WSR concept plans because storage capacity is the most influential factor in determining benefits to water supply reliability for this study. Hence, three dam raises were considered in the WSR concept plans: 6.5 feet, 18.5 feet, and 202.5 feet. The concept plans summarized in Table 4-1 and described below are believed to be reasonably representative of the range of potential actions to address the primary planning objective of water supply reliability.

The majority of water supply reliability benefits for all water supply reliability plans consist of increases in south-of-Delta agricultural water deliveries. The remaining benefits are seen in increased water deliveries for south-of-Delta M&I and north-of-Delta agricultural and M&I uses.

WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 Feet)

WSR-1 focuses on the primary planning objective of water supply reliability by increasing the volume of water stored in Shasta Lake with a 6.5-foot dam raise. Major components of this concept plan include (1) raising Shasta Dam by 6.5 feet for the primary purpose of creating 290,000 acre-feet of additional storage available for water supply and (2) revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. This plan is similar to AFS-1, but the additional storage would be operated for water supply reliability as under existing operational guidelines. Similar to AFS-1, this concept plan would increase the capacity of the reservoir by 290,000 acre-feet to a total of 4.84 MAF and extend the existing TCD for efficient use of the expanded cold-water pool.

In addition, WSR-1 includes revisions to the operational rules for flood control such that the facility could potentially be managed more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply. This would be accomplished using advanced weather forecasting tools. A primary constraint of this component of WSR-1 is that the existing level of flood protection provided by Shasta Dam would not be adversely impacted.

Major benefits of WSR-1 include the following:

- **Anadromous Fish Survival –** Although the focus of WSR-1 is on improving water supply reliability, raising Shasta Dam also would increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about half that for AFS-1.

- **Water Supply Reliability** – WSR-1 would increase water supply reliability by increasing critical and dry year water supplies for CVP and SWP deliveries. This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 72,000 acre-feet per year. This increase in reliability also could help reduce supplies redirected by the CVPIA during drought years by about 13 percent.

- **Other Benefits –** The higher water surface elevation in the reservoir would result in a net increase in power generation. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. WSR-1 does not include any specific measures to address the secondary planning objective of environmental restoration. Similar to the AFS plans, WSR-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area. The maximum surface area of the lake would increase by about 1,100 acres (3 percent), from 29,600 to about 30,700 acres.

WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 Feet)

WSR-2 focuses on the primary planning objective of water supply reliability by raising Shasta Dam 18.5 feet. The major components of this plan include (1) raising Shasta Dam by 18.5 feet for the primary purpose of creating 634,000 acre-feet of additional storage available for water supply and (2) revising flood control operations to benefit water supply reliability by managing floods more efficiently.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. Although higher dam raises are technically and physically feasible, 18.5 feet is the largest practical dam raise that does not require relocating the Pit River Bridge. The 18.5-foot raise would increase the capacity of the reservoir by 634,000 acre-feet to a total of 5.19 MAF (see Table 4-2). Operations for the added storage in the reservoir would be similar to existing operations. The existing TCD would be extended for efficient use of the expanded cold-water pool. As described for WSR-1, this concept plan would include modifying flood control operation rules to manage the reservoir more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply.

The plan includes constructing a protection dike for I-5 at Lakeshore Drive and the UPRR at Bridge Bay. To offset potential impacts to lake area infrastructure, the plan would include modifications to the Pit River Bridge, replacement of 7 other bridges, acquisition and/or relocation of 130 structures, and relocation of small segments of existing paved and nonpaved roads. In addition, two power transmission lines, several water storage tanks, and three USFS fire stations and ancillary facilities also would be relocated. Portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road would be relocated. To offset potential impacts to seasonal boat traffic under the Pit River Bridge, the plan would need to include features such as boat scheduling assistance and/or financial compensation.

The primary benefits of WSR-2 include the following:

- **Anadromous Fish Survival –** Although the focus of WSR-2 is on improving water supply reliability, raising Shasta Dam by 18.5 feet would increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population of about 30 percent over AFS-1.

- **Water Supply Reliability –** WSR-2 would increase water supply reliability by increasing the critical and dry year water supplies for CVP and SWP deliveries. This would help reduce estimated future shortages by increasing critical and dry period supplies by at least 125,000 acre-feet per year. This increase in reliability could also help reduce CVPIA-redirected supplies during drought years by about 20 percent.

- **Other Benefits –** The higher water surface elevation in the reservoir would result in a net increase in power generation of about 44 GWh per year. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. WSR-2 does not include any specific measures to address the secondary planning objective of environmental restoration. The water-oriented recreation experience at Shasta Lake would generally increase due to the increase in lake surface area. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)

WSR-3 focuses on the primary planning objective of water supply reliability by raising Shasta Dam by 202.5 feet. Major components of this plan include (1) raising Shasta Dam by about 202.5 feet for the primary purpose of creating 9.3 MAF of additional storage available for water supply and (2) major modifications to or replacing dam appurtenances, including hydropower facilities and the TCD.

Raising Shasta Dam by about 202.5 feet is considered to be the largest technically feasible raise without completely reconstructing the existing dam. The 202.5-foot raise would increase the capacity of the reservoir by 9.3 MAF to a total of 13.9 MAF. The magnitude of this raise would require significant modifications or replacement of most facilities associated with the dam (see Table 4-2). The existing TCD would be replaced, and modifications to hydropower facilities would include replacing gates and structural supports for the penstocks, adding generator units to the powerplant, replacing the switchyard, and modifying Keswick Dam and its powerplant. The additional storage in the reservoir would be operated primarily for water supply, but the magnitude of the raise also would significantly increase the cold-water pool and the ability of dam operators to meet both temperature and minimum flow requirements on the upper Sacramento River.

Because of the extensive area impacts associated with WSR-3, the plan would need to include major facilities aimed at offsetting these impacts. At minimum, they would include relocating the Pit River Bridge, replacing 20 other bridges, removing Pit 7 Dam, relocating about 630 structures, and inundating numerous large segments of existing paved and nonpaved roads. About 35 miles of the UPRR, 19 miles of I-5, and numerous associated tunnels, embankments, and other facilities would be relocated. The plan would need to include significant facilities to mitigate for impacts to reservoir area recreation facilities. The plan would include extensive facilities to mitigate impacts to environmental, historical, and other cultural resources around Shasta Lake.

The Pit 7 Dam is located at the existing headwater of Shasta Lake (see Figure 4-2). The dam is 200 feet high and was constructed for hydropower purposes in the mid-1960s by PG&E. The full pool elevation for WSR-3 would be similar to the existing top of the Pit 7 Dam, inundating all facilities at the dam. Electric generation lost at Pit 7 would be replaced from the facilities added at the enlarged Shasta Dam.

Figure 4-2. Pit 7 Dam, Located on the Pit River Upstream from Shasta Lake, is 200 Feet High

Major benefits of WSR-3 include the following:

- **Anadromous Fish Survival –** Raising Shasta Dam by 202.5 feet would substantially increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. Preliminary analyses indicate that improved water temperature conditions could result in a major average increase in salmon population. The additional storage also would provide operators with greater flexibility in meeting minimum flow requirements on the upper Sacramento River. Detailed studies are required to more accurately quantify the increase in anadromous fish populations resulting from such a large increase in the capacity of Shasta Dam and Reservoir.

- **Water Supply Reliability –** WSR-3 would significantly increase water supply reliability for the CVP and SWP systems. This would help reduce estimated future shortages, increasing critical and dry period supplies by over 700,000 acre-feet per year. This increase in reliability would likely offset CVPIA-redirected supplies during drought years.

- **Other Benefits –** The higher water surface elevation in the reservoir would result in a significant net increase in power generation, amounting to almost 2.3 million GWh per year. Much of this increase would be offset, however, by the loss of generation from the Pit 7 Dam, which would be removed. A potential would also exist to significantly increase the ability to control larger flood events in the Sacramento River near Redding. WSR-3 does not include any specific measures to address the secondary planning objective of environmental restoration. The water-oriented recreation experience at Shasta Lake would generally increase because of the increase in lake surface area. The maximum surface area of the lake would increase by about 31,200 acres (roughly twice that of existing conditions), from 29,600 to about 60,800 acres.

WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 Feet) and Conjunctive Water Management

WSR-4 focuses on the primary planning objective of water supply reliability by raising Shasta Dam 18.5 feet in combination with conjunctive water management. Major components of this plan include (1) raising Shasta Dam by 18.5 feet for the primary purpose of creating 634,000 acre-feet of additional storage available for water supply and (2) implementing a conjunctive water management program.

Each of these components focuses on increasing water supply reliability to the CVP and SWP. The 18.5-foot raise would increase the capacity of the reservoir by 636,000 acre-feet to a total of 5.19 MAF (see Table 4-2). Operations for the added storage in the reservoir would be similar to existing operations. The existing TCD would be extended for efficient use of the expanded cold-water pool. As described for WSR-1, this concept plan would include modifying flood control operation rules to manage the reservoir more efficiently for flood control, thereby freeing some additional seasonal storage space for water supply.

The conjunctive water management component would consist largely of contract agreements between Reclamation and certain Sacramento River basin water users. It also would include any additional river diversions, increase in current diversion capacity, and/or transmission facilities to facilitate the exchange.

Major benefits of WSR-4 include the following:

- **Anadromous Fish Survival –** Raising Shasta Dam by 18.5 feet would increase the cold-water pool and benefit seasonal water temperatures along the upper Sacramento River. It is estimated that improved water temperature conditions could result in an average increase in the salmon population similar to AFS-1.

- **Water Supply Reliability –** WSR-4 would increase water supply reliability by increasing the critical and dry year water supplies for CVP and SWP deliveries. The combination of increased storage space in Shasta Reservoir and exchanged surface water for participating Sacramento River water users would result in an increase in water supply reliability of about 146,000 acre-feet per year. This increase in reliability could also help reduce CVPIA-redirected supplies during drought years.

- **Other Benefits–** The higher water surface elevation in the reservoir would result in a net increase in power generation. Flood control operations at Shasta Dam and Reservoir would continue similar to under existing conditions. WSR-4 does not include any specific measures to address the secondary planning objective of environmental restoration. The water-oriented recreation experience at Shasta Lake would generally increase because of the increase in lake surface area. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Plans Focused on Combined Objectives

Various concept plans were formulated from the retained management measures to represent a reasonable balance between the two primary planning objectives. Five of the plans are shown in Table 4-1. The CO concept plans shown in the table and described below include measures to actively address the secondary planning objectives, as appropriate. As with previous concept plans, numerous potential sizes and combinations of components are possible. However, for comparison purposes, three CO concept plans described below include raising Shasta Dam by 18.5 feet and two involve raising Shasta Dam by 6.5 feet. It is believed that they are reasonably representative, although not exhaustively, of the range of potential and applicable actions.

CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)

CO-1 addresses both primary planning objectives by restoring anadromous fish habitat and raising Shasta Dam by 6.5 feet.

CO-1 includes the following major components:

- Raising Shasta Dam by 6.5 feet for the purposes of expanding the cold-water pool and creating 290,000 acre-feet of additional storage available for water supply.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-1 would use the additional storage created by the 6.5-foot raise to increase water supply reliability, while also improving the ability to meet water temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 290,000 acre-feet to a total of 4.84 MAF, and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for aquatic and floodplain restoration from one or more abandoned gravel mines on the upper Sacramento River (see previous discussion of AFS-3).

Benefits of CO-1 are described below:

- **Anadromous Fish Survival –** CO-1 would increase the ability of Shasta Dam to make cold-water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critical years. Preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 410 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.
- **Water Supply Reliability –** CO-1 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 72,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** Higher water surface elevations in the reservoir would result in a small net increase in power generation of about 15 GWh per year.

- **Other Benefits –** CO-1 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating a 6.5-foot raise. The maximum surface area of the lake would increase by about 1,060 acres (3 percent), from 29,600 to about 30,700 acres.

CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

CO-2 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet and restoration of anadromous fish habitat.

CO-2 includes the following major components:

- Raising Shasta Dam by 18.5 feet for the purposes of expanding the cold-water pool and creating 636,000 acre-feet of additional storage available for water supply.

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.

- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-2 is similar to CO-1, except Shasta Dam would be raised 18.5 feet instead of 6.5 feet. The additional storage created by the 18.5-foot dam raise would be used to increase water supply reliability, while also improving the ability to meet water temperature objectives for winter-run salmon. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 MAF, and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for aquatic and floodplain restoration from one or more abandoned gravel mines (see previous discussion of AFS-3).

Benefits of CO-2 are described below:

- **Anadromous Fish Survival –** CO-2 would increase the ability of Shasta Dam to make cold-water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critical years. Preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 1,110 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-2 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 125,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** The higher water surface elevations in the reservoir would result in a net increase in power generation of about 44 GWh per year. The ability to control floods may increase by a small degree.

- **Other Benefits –** CO-2 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)

CO-3 addresses both primary planning objectives by raising Shasta Dam by 18.5 feet, restoring anadromous fish habitat, and improving flow conditions on the upper Sacramento River.

CO-3 includes the following major components:

- Raising Shasta Dam by 18.5 feet, expanding the cold-water pool, and creating 636,000 acre-feet of additional storage available for both water supply and flow regulation.

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.

- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

CO-3 is similar to CO-2, except a portion of the additional storage created by the 18.5-foot dam raise would be dedicated to managing flows for winter-run salmon on the upper Sacramento River. The additional storage space could be allocated to fisheries and water supply reliability in many different ways; additional investigation would be needed to assess combinations that could best address the two major objectives. For the purpose of this initial analysis, dedicating about 320,000 acre-feet to increasing minimum flows is believed to be a good estimation of the potential benefits of this concept.

Minimum flows on the upper Sacramento River would be increased from 3,250 cfs to about 4,200 cfs between October 1 and April 30 (see previous discussion of AFS-2), consistent with the Anadromous Fish Restoration Program. Suitable areas totaling 150 acres would be chosen for restoration from one or more abandoned gravel mines (see previous discussion of AFS-3). Temperature benefits also would be gained by increasing the size of the cold-water pool.

The existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revisions to the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1).

Benefits of concept CO-3 are described below:

- **Anadromous Fish Survival –** CO-3 would benefit anadromous fish by increasing seasonal minimum flows and improving water temperature conditions in the upper Sacramento River, primarily in dry and critical years. Significant additional effort is needed to reliably quantify potential benefits to the anadromous fish population from this concept. However, preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 980 salmon. Habitat restoration and minimum flow increases would add an additional 320 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-3 would increase average and dry period water supply reliability to the CVP and SWP systems. This increase corresponds to about 90,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** Higher water surface elevations in the reservoir would result in a net increase in power generation of about 61 GWh per year. The ability to control floods may increase to a small degree.

- **Other Benefits –** CO-3 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise.

CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)

CO-4 addresses the primary and secondary planning objectives through raising Shasta Dam 6.5 feet in combination with conjunctive use, habitat restoration, and environmental restoration in the Shasta Lake area and upper Sacramento River.

CO-4 includes the following major components:

- Raising Shasta Dam by 6.5 feet, expanding the cold-water pool, and creating 290,000 acre-feet of additional storage available for water supply reliability.
- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.
- Implementing a conjunctive water management program.
- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.
- Restoring 500 acres of wetland and riparian habitat along the Sacramento River at one or more sites between Redding and Red Bluff.

CO-4 addresses both primary and secondary objectives of the SLWRI through a combination of measures. It would improve anadromous fish survival by increasing the cold water pool in Shasta Reservoir and restoring 150 acres of valuable aquatic and floodplain habitat on the upper Sacramento River. The concept would improve water supply reliability through increasing the storage space in Shasta Reservoir by 290,000 acre-feet, implementing conjunctive water management, and re-operating the reservoir more efficiently for flood control. The secondary objective of environmental restoration also would be addressed through shoreline and tributary habitat improvements around Shasta Lake, and riparian restoration along the upper Sacramento River.

CO-4 includes restoring (1) resident fish habitat in Shasta Lake and (2) riparian habitat at four locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek (see Figure 4-3).

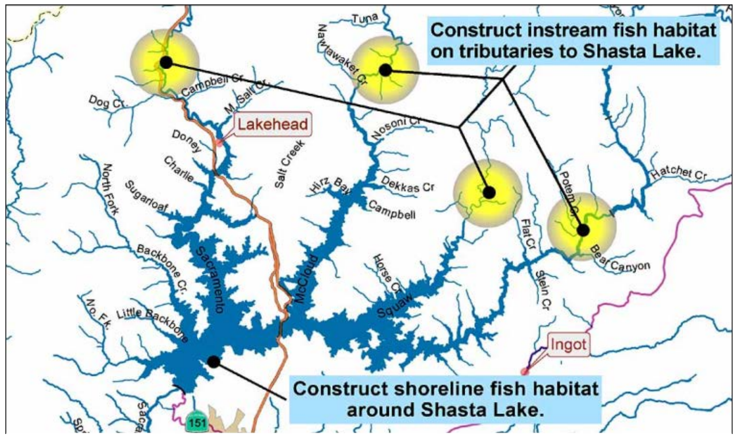

Figure 4-3. Potential Ecosystem Restoration Features in the Shasta Lake Area

This component includes improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. These improvements would help provide favorable spawning conditions; juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Establishing vegetation also could benefit terrestrial species that inhabit the shoreline of Shasta Lake.

This concept also includes improving and restoring instream aquatic habitat along the lower reaches of major tributaries to Shasta Lake using various structural techniques to trap spawning gravel in deficient areas, create pools and riffles, provide instream cover, and improve overall instream habitat conditions. Treatments could include installing gabions, log weirs, boulder weirs, and other anchored structures. Spawning and rearing habitat would be created by installing instream cover, such as large root wads, and drop structures, boulders, gravel traps, and/or logs that cause scouring and help clean gravel. The lower reaches of perennial tributaries to Shasta Lake would be targeted for aquatic restoration because they provide year-round fish habitat.

Also included in CO-4 is acquisition and restoration of wetland and riparian areas along the upper Sacramento River. The location and total area of potential restoration will be the subject of future studies. However, for initial planning purposes, restoration of 500 acres along the Sacramento River between Keswick and Red Bluff is included in this concept.

Major benefits of CO-4 are described below:

- **Anadromous Fish Survival –** CO-4 would benefit anadromous fish by improving water temperature conditions in the upper Sacramento River, primarily in dry and critical years, and increasing the quality and quantity of aquatic habitat. Significant additional effort is needed to reliably quantify potential benefits to the anadromous fish population from this concept. However, preliminary analyses estimate that improved water temperature conditions could result in an average annual increase of 410 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-4 would increase average and dry period water supply reliability to the CVP and SWP systems through reservoir expansion and conjunctive water management. This increase corresponds to about 89,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** CO-4 includes restoring resident fish habitat in Shasta Lake and riparian habitat at four locations along the lower arms of the Sacramento River, McCloud River, and Squaw Creek. An additional 548 acres of riparian and wetland habitat would be acquired and restored along the upper Sacramento River. The location and total area of restoration in the Shasta Lake and upper Sacramento River areas will be the subject of future studies. Minor increases in hydropower production and flood protection would occur.

- **Other Benefits –** CO-4 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating a 6.5-foot raise.

CO-5 – Multipurpose with Shasta Enlargement (18.5 feet)

CO-5 addresses both primary planning objectives by raising Shasta Dam 18.5 feet in combination with conjunctive water management and anadromous fish habitat restoration.

Major plan components of CO-5 include the following:

- Raising Shasta Dam by 18.5 feet, expanding the cold-water pool, and creating 636,000 acre-feet of additional storage available for water supply.

- Implementing a conjunctive water management program.

- Acquiring, restoring, and reclaiming one or more inactive gravel mining operations along the upper Sacramento River to create about 150 acres of aquatic and floodplain habitat.

- Revising flood control operations to benefit water supply reliability by managing floods more efficiently.

- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of the Sacramento River, McCloud River, and Squaw Creek.

- Restoring 500 acres of wetland and riparian habitat at one or more sites between Redding and Red Bluff on the Sacramento River.

CO-5 is similar to CO-4, except Shasta Dam would be raised 18.5 feet instead of 6.5 feet. The additional storage created by the 18.5-foot dam raise would be used primarily to increase water supply reliability, while also improving the ability to meet water temperature objectives for winter-run salmon during drought years. The capacity of the reservoir would increase by 636,000 acre-feet to a total of 5.19 MAF and the existing TCD would be extended to achieve efficient use of the expanded reservoir. This concept also would include revising the operational rules for flood control, such that Shasta Dam and Reservoir could be managed more efficiently for water supply reliability (see previous discussion of WSR-1). Suitable areas totaling 150 acres would be chosen for restoration from one or more abandoned gravel mines (see previous discussion of AFS-3). As with CO-4, the secondary objectives of environmental restoration would be addressed through shoreline and tributary habitat improvements around Shasta Lake, and 500 acres of riparian restoration along the upper Sacramento River.

Major benefits of CO-5 include the following:

- **Anadromous Fish Survival –** CO-5 would increase the ability of Shasta Dam to make cold-water releases to regulate water temperature in the upper Sacramento River, primarily in dry and critical years. Preliminary analyses estimate that improved temperature conditions could result in an average annual increase of 1,110 salmon. Habitat restoration would add an additional 150 acres of aquatic and floodplain habitat to the Sacramento River between Keswick and Battle Creek, a critical spawning reach.

- **Water Supply Reliability –** CO-5 would increase average and dry period water supply reliability to the CVP and SWP systems through increasing the capacity of Shasta Lake in combination with conjunctive water management. This increase corresponds to about 146,000 acre-feet during critical years.

- **Environmental Restoration, Flood Control, and Hydropower –** Higher water surface elevations in the reservoir would result in a net increase in power generation of about 44 GWh per year. The ability to control floods may increase by a small degree. An additional 500 acres of riparian and wetland habitat would be acquired and restored along the upper Sacramento River between Red Bluff and Redding. The location and total area of restoration in the Shasta Lake and upper Sacramento River areas will be the subject of future studies.

- **Other Benefits –** CO-5 would provide a small benefit to the water-oriented recreation experience at Shasta Lake due to the increase in lake surface area, similar to that described previously for concepts incorporating an 18.5-foot raise. The maximum surface area of the lake would increase by about 2,500 acres (8 percent), from 29,600 to about 32,100 acres.

Summary Comparison of Concept Plans

To help focus the plan formulation process and select the most appropriate plans to be carried forward for further development, the concept plans were compared considering two basic planning criteria: effectiveness and efficiency. These are two of four criteria identified in the P&G for water resources planning, in addition to completeness, and acceptability. Below is a description of the two criteria and their application. Table 4-3 shows the resulting comparison of the concept plans based on their relative ability to address each of the criteria. As can be seen in the table and described below, each plan was assigned a relative ranking ranging from very low to very high for each criterion. Each comparison criterion for the concept plans in the table received the same weighting and resulted in an overall relative ranking. This overall ranking was used, along with other information, to determine if a concept plan should be considered further in the plan formulation process in the SLWRI.

Effectiveness

Effectiveness is the extent to which a plan alleviates problems and achieves objectives. For the primary planning objective of anadromous fish survival, two major relative ranking factors were considered: (1) increasing salmon survival (decreased salmon mortality) and (2) increasing habitat for spawning. For water supply reliability, ranking was based on the relative amount of increased dry and critical year water supplies for CVP and SWP deliveries that could be derived from each concept plan. For the secondary planning objectives, three relative ranking factors were considered: (1) whether a plan included ecosystem restoration, (2) potential to affect flood peaks downstream from Keswick Dam, and (3) potential to increase net electric energy. Primary planning objectives received 80 percent of the weight and secondary planning objectives received 20 percent of the weight for this criterion.

As indicated in Table 4-3, concept plans with the greatest effectiveness in meeting planning objectives are WSR-3, CO-2, and CO-5. This is primarily because, of the 12 concept plans, these three would generally result in the greatest combined contribution to both primary planning objectives. Each AFS-focused plan, when compared to other concept plans, ranks low primarily because the AFS plans would provide limited benefits to other planning objectives. The same conclusions apply to the larger sizes of raising Shasta Dam.

Table 4-3. Summary Comparison of Concept Plans

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	**Efficiency**	
AFS-1 – Increase Cold-Water Assets with Shasta Operating Pool Raise (6.5 feet)	Significantly effective in helping benefit anadromous fish survival. Does not significantly contribute to water supply reliability if all storage is dedicated to fisheries purposes. Incidental contribution to flood control and hydropower objectives.	Because contributes to only one primary planning objective (anadromous fish survival), results in greatest cost for that purpose.	Enlarging Shasta only for increasing the cold-water pool is **identified** for further consideration as a stand-alone plan. Although this plan addressed only one primary planning objective, if considered in a larger plan (allocation of space), this plan might be found feasible.
Relative Rank	*Moderate*	*Low*	*Moderate*
AFS-2 – Increase Minimum Anadromous Fish Flow with Shasta Enlargement (6.5 feet)	Relatively low increase in fish habitat with uncertain benefit to increased survival. Major trade-off in water supply reliability for relatively minor increased minimum flows. Incidental contribution to flood control and hydropower objectives.	Very high unit costs for increased fish habitat. Also, very high unit cost for water supply reliability. High costs due to dedicating storage space to increasing minimum winter/spring flows with little contribution to water supply.	Enlarging Shasta primarily to increase winter/spring river flows for anadromous fish is **not identified** for further consideration as a stand-alone plan. Very high costs for marginal increases in meeting objectives. Same conclusion for any sized project with similar component measures. However, potential operational changes to increase fish survival are **identified** for further study as part of any plan considered.
Relative Rank	*Low*	*Low*	*Low*
AFS-3 – Increase Minimum Anadromous Fish Flow and Restore Aquatic Habitat with Shasta Enlargement (6.5 feet)	Similar to AFS-2. Increased effectiveness in anadromous fish habitat through gravel mine restoration.	Similar to AFS-2. Very high unit costs to meet primary planning objective.	Similar to AFS-2, **not identified** for further consideration as a stand-alone plan. High costs for marginal increases in meeting objectives.
Relative Rank	*Low*	*Low*	*Low*
WSR-1 – Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)	Relatively low potential to effectively increase water supply reliability and improve fish survival. Incidental contribution to flood control and hydropower objectives.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects.	Enlarging Shasta primarily for water supply reliability from sizes 6.5 feet to about 18.5 feet is **identified** for further development primarily because (1) consistent with goals of the 2000 CALFED Programmatic ROD, (2) high cost-efficiency compared to other new sources, and (3) provides significant incidental benefits to anadromous fish and secondary study objectives.
Relative Rank	*Low*	*Moderate*	*Moderate*

Table 4-3. Summary Comparison of Concept Plans (contd.)

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	**Efficiency**	
WSR-2 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)	Moderate potential to effectively address primary planning objectives. Significant contribution to water supply reliability. Incidental contribution to flood control and hydropower objectives.	Very high cost-efficiency. Superior to all other known new sources, including potential surface water storage projects.	**Identified** for further development for reasons similar to WSR-1. Also, enlarging Shasta to maximum extent possible without major relocations can maximize cost-efficiency.
Relative Rank	*Moderate*	*Very High*	*High to Very High*
WSR-3 – Increase Water Supply Reliability with Shasta Enlargement (High Level)	High potential to significantly address primary planning objectives. Significantly addresses water supply reliability. Can contribute significantly to cold-water salmon resources. Provides major opportunities to address secondary planning objectives.	Very high implementation cost. Relatively high unit cost for new water supplies.	**Not Identified** for further consideration at this time. High social and environmental impacts in Shasta Lake area. Very high implementation cost.
Relative Rank	*High*	*Low*	*Low*
WSR-4 – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet) and Conjunctive Water Management	Similar to WSR-2 with increased contribution to water supply reliability through conjunctive use management. However, significantly diminishes potential increased fish survival benefits.	High cost-efficiency for water supply reliability. Estimated to result in the lowest unit cost of all plans considered and of all other known potential water supply reliability projects.	Enlarging Shasta to maximum extent possible without major relocations and including conjunctive water management component is **not identified** for further development. Although cost-efficient, it diminishes fish survival benefits to achieve additional water supply reliability. No known active support for a conjunctive use component.
Relative Rank	*Low*	*Very High*	*Moderate to High*
CO-1 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (6.5 feet)	Potential to address primary planning objectives with emphasis on spawning habitat restoration. Contributes to cold-water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply.	Unit cost for water supply reliability competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along the upper river.	**Not identified** for further consideration as a stand-alone plan. Major components are redundant with WSR-1 and CO-2, which are recommended for further development.
Relative Rank	*Moderate*	*Moderate*	*Moderate*

Table 4-3. Summary Comparison of Concept Plans (contd.)

Concept Plans	Comparison Criteria: Effectiveness	Comparison Criteria: Efficiency	Identified Status and Relative Ranking
CO-2 – Increase Anadromous Fish Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Similar to CO-1, but with increased potential to address primary and several secondary planning objectives due to increased storage space.	High cost-efficiency. Unit cost for water supply reliability highly competitive with other new sources, including potential surface water storage projects. High potential for efficient salmon habitat restoration along the upper river.	Enlarging Shasta to the maximum extent possible (without major relocations), and including features to increase anadromous fish habitat is **identified** for further development. Recommended primarily because this plan is (1) consistent with goals of the CALFED Programmatic ROD, (2) highly cost efficient, and (3) addresses most of the planning objectives.
Relative Rank	*High*	*High*	*High*
CO-3 – Increase Anadromous Fish Flow/Habitat and Water Supply Reliability with Shasta Enlargement (18.5 feet)	Low to moderate potential to effectively address primary objectives. Potential to significantly benefit salmon resources through restoring fish habitat. Provides major opportunities to address secondary objectives.	Reduced cost-efficiency for water supply reliability due to dedicated increased minimum flows.	For reasons similar to AFS-2 and AFS-3, enlarging Shasta with significant storage space dedicated to increased winter/spring flows for anadromous fish is **not identified** for further consideration as a stand-alone plan at this time. Very high costs for marginal increases in meeting objectives. However, potential operational changes to increase fish survival are recommended for further study as part of any plan considered.
Relative Rank	*Moderate*	*Moderate*	*Moderate*
CO-4 – Multipurpose with Shasta Enlargement (6.5 feet)	Moderate potential to address primary planning objectives, with emphasis on spawning habitat restoration. Contributes to cold-water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	Most cost-efficient plan for a 6.5-foot dam raise. Moderate potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	**Not identified** for further consideration as a stand-alone plan with a 6.5-foot raise, primarily due to reduced effectiveness and efficiency. Major components are redundant with WSR-1 and CO-5, which are recommended for further development.
Relative Rank	*Moderate*	*Moderate*	*Moderate*

Table 4-3. Summary Comparison of Concept Plans (contd.)

Concept Plans	Comparison Criteria		Identified Status and Relative Ranking
	Effectiveness	**Efficiency**	
CO-5 – Multipurpose with Shasta Enlargement (18. 5 feet)	High potential to address primary planning objectives with emphasis on spawning habitat restoration. Significantly contributes to cold-water salmon resources and reduced mortality. Includes features to increase reservoir reoperation for flood control and water supply. Includes features to help restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	High cost-efficiency for water supply reliability. High potential for efficient salmon habitat restoration along upper river. High potential for helping restore ecosystem resources along the upper Sacramento River and near Shasta Lake.	Enlarging Shasta to the maximum extent possible (without major relocations), and including features for conjunctive water management, anadromous fish habitat, and ecosystem restoration is **identified** for further development. Recommended primarily because this plan is (1) consistent with goals of the 2000 CALFED Programmatic ROD, (2) highly cost-efficient, and (3) addresses all planning objectives.
Relative Rank	*High*	*High*	*High*

Key:
AFS = Anadromous Fish Survival
CALFED = CALFED Bay-Delta Program
CO = Combined Objective
ROD = Record of Decision
WSR = Water Supply Reliability

Anadromous Fish Survival This subcriterion is the relative ability of a plan to help increase the survival of anadromous fish populations in the Sacramento River primarily upstream from the Red Bluff. Included in Table 4-4 is a preliminary estimate of the average annual increase in Chinook salmon populations upstream from the Red Bluff only, resulting from the increase in the cold-water pool in Shasta Reservoir for three dam enlargements and reservoir operations.

For dam raises of 6.5 feet, the greatest benefit to fish survival would occur with AFS-1 because all additional space would be dedicated to the goal of increasing the cold-water pool. However, AFS-1 would not significantly contribute to the other planning objectives. The next greatest increase in fish survival with a dam raise of 6.5 feet would occur equally with WSR-1, CO-1, and CO-4. The least apparent benefit in increased salmon survival would occur with AFS-2 and AFS-3. This is because increasing minimum flows on the upper Sacramento River would deplete the cold-water pool, which may be needed later in the year for temperature regulation during the warm summer months. Also for these two concept plans, the potential to benefit other objectives would be low. It is expected that similar relationships would occur for larger dam raises but with increasing effectiveness for anadromous fish survival.

As mentioned, AFS-3, CO-1, CO-2, CO-3, CO-4, and CO-5 all included restoration of one or more abandoned gravel mines along the upper Sacramento River downstream from Keswick Dam for anadromous fish survival benefits. Recent evaluations related to the use of the SALMOD model have indicated that restoring these areas may not result in a significant benefit to anadromous fish. Concerns have been expressed ranging from a low likelihood that these areas could be effectively used to increase spawning and rearing habitats to the likelihood for increased predation. Further, during public and stakeholder outreach meetings in late 2005 held primarily for environmental scoping purposes, there was little to no interest expressed for acquisitioning and restoring these areas. At this time, restoration of abandoned gravel mines is not included in further plan formulation activities for the SLWRI.

The estimated difference in increased fish survival benefits between WSR-2 or CO-2 and WSR-4 or CO-5 (dam raises of 18.5 feet) is because including a conjunctive management component in the concept plans would lessen the amount of cold-water available during critical periods compared to operations without the conjunctive management component. Although the relative increase in water supplies is sizeable, so are the benefits forgone for anadromous fish survival when a conjunctive use component is included. The greatest benefit to anadromous fish from an increase in the cold-water pool would be with WSR-3 (dam raise of 202.5 feet). It is believed, however, that this plan could have adverse impacts not yet defined that would discount the apparent increase in salmon survival.

Table 4-4. Summary of Estimated Costs and Benefits for Concept Plans

Item	Concept Plans											
	Anadromous Fish Survival Focus			Water Supply Reliability Focus				Combined Objective Focus				
	AFS-1	AFS-2	AFS-3	WSR-1	WSR-2	WSR-3	WSR-4	CO-1	CO-2	CO-3	CO-4	CO-5
Raise Shasta Dam (feet)	**6.5**	**6.5**	**6.5**	**6.5**	**18.5**	**202.5**	**18.5**	**6.5**	**18.5**	**18.5**	**6.5**	**18.5**
Total Increased Storage (1,000 acre-feet)[1]	290	290	290	290	636	9340	636	290	636	636	290	636
Accomplishments												
Anadromous Fish												
- Spawning Habitat - Restore Gravel Mines (acres)	-	-	150	-	-	-	-	150	150	150	150	150
- Minimum Flows (acres)	-	170	170	-	-	-	-	-	-	170	-	-
- Average Annual Salmon Increase (1,000 fish)[2]	860	370	370	410	1,110	10,620	1,020	410	1,110	980	410	1,020
Water Supply Reliability (1,000 acre-feet/year)[3]	0	20	20	72	125	703	146	72	125	90	89	146
Ecosystem Restoration (acres)	-	-	-	-	-	-	-	-	-	-	548	548
Hydropower Generation (GWh/yr)[4]	51	32	32	15	44	2,254	44	15	44	61	12	44
Flood Damage Reduction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Construction Cost ($millions)[5]	282	282	292	282	408	5,250	459	292	418	418	356	483

Notes:

1 Early evaluations estimated the storage capacity increase with a 6.5-foot raise at 290,000 acre-feet as indicated in Table 4-2

2 Average Annual Salmon Increase numbers are from Initial Alternatives Information Report (simulated using SALMOD), June 2004. Updated modeling results can be found in the Modeling Appendix.

3 Approximate increased water supplies for CVP and SWP deliveries from the 2004 Initial Alternatives Information Report simulated with CalSim-II based on drought year conditions with Banks Pumping capacity at 6,680 cfs. At 8,500 cfs pumping capacity, increased water supplies are about 18 percent greater.

4 Preliminary estimate based on 2003 conditions.

5 Based on preliminary designs and cost estimates at 2003 price levels.

Key:
AFS = anadromous fish survival
CO = combined objective
GWh/yr = gigawatt hours per year
WSR = water supply reliability

Water Supply Reliability This subcriterion is the relative potential of a plan to help increase water supplies and water supply reliability to the CVP and SWP to help meet current and future water demands, with a primary focus on modifying Shasta Dam and Reservoir. Included in Table 4-4 is an estimate of the increase in drought period water supply reliability for the concept plans. As can be seen, the increase in water supply reliability ranges from about 20,000 acre-feet per year for dam raise of 6.5 feet (including dedication of increased storage to increasing spring fish flows) to over 700,000 acre-feet per year for a dam raise of 202.5 feet. The exception is concept plan AFS-1, which would provide only an incidental amount of increased water supply for system deliveries.

Ecosystem Restoration This subcriterion is a measure of the ability of a plan to address the secondary planning objective of ecosystem restoration. Through pursuit of the primary planning objectives, significant potential is created to implement features to help conserve and restore ecosystem resources, especially in the Shasta Lake area.

Flood Control This subcriterion includes a measure of the ability of a plan to reduce flood damages along the upper Sacramento River near Redding. Each of the concept plans has the potential to incidentally provide increased flood control opportunities. However, for any of the plans other than WSR-3, this possibility is very small, unless the projects were operated (at least in part) specifically for that purpose. However, there does not appear to be sufficient residual need for an additional flood control increment in Shasta Reservoir.

This subcriterion also addresses increases in public safety at Shasta Dam. All of the concept plans include routing the PMF from the top of conservation space in Shasta Reservoir. As mentioned, this results in additional features at Shasta Dam and around Shasta Reservoir to more safely accommodate extremely rare and large flood events such as the PMF.

Hydropower This subcriterion is a measure of the ability of a plan, through pursuit of the primary planning objectives, to help increase hydropower capabilities at Shasta Dam. Each of the plans incidentally provides increased opportunities for hydropower generation. From Table 4-4, based on 2003 conditions, it is estimated that increases in hydropower generation would range from about 15 GWh/year for WSR-1 to over 2,200 GWh/year for WSR-3 (not including loss of generation at the Pit 7 Dam).

Efficiency

Efficiency is the measure of how efficiently a plan alleviates identified problems while realizing specified objectives consistent with protecting the Nation’s environment. Concept plans ranking highest for this criterion are WSR-2, WSR-4, CO-2, and CO-5. This is primarily because each of these plans provides a significant increase in water supply reliability at a relatively low unit cost while significantly contributing to other planning objectives. Each of the AFS-focused concept plans and WSR-3 rank low. For the AFS-focused plans, this is primarily because the increased storage space would be dedicated to either increasing the cold-water pool or instream flows. These plans would provide very little economic benefit to the other planning objectives. However, plans could be simulated to dedicate some of the storage space to water supply and some to anadromous fish, which would result in lowered traditional economic benefits but increased fisheries benefits.

Anadromous Fish Survival Under the efficiency criterion, this is the measure of the potential for a plan to increase the long-term survivability of anadromous fish in the upper Sacramento River at the lowest incremental cost. Through use of SALMOD and by assessment of other features, it is estimated that the most efficient way to significantly and effectively increase the survivability of anadromous fish in the upper Sacramento River is through increases in the cold-water pool in Shasta Lake that would result in cooler water releases during critical periods of the year. Other ways of helping improve the fishery are included in several concept plans such as increased winter/spring minimum flows and habitat restoration. These measures were found to be less effective and had a higher uncertainty for success than increasing the cold-water pool in the lake.

Water Reliability Unit Cost
This is a measure of the potential for a plan to increase the reliability of the CVP and SWP by developing a reliable additional increment of water at the lowest unit cost (dollars per acre-foot of increased dry and critical year deliveries). It is estimated that concept plans WSR-2, WSR-4, CO-2, and CO-5 would result in the lowest unit water costs compared to the other plans considered. Excluding AFS-1, concept plans that would result in the highest unit cost for increased water supply reliability are AFS-2, AFS-3, WSR-1, and WSR-3.

Secondary Planning Objective Costs
This is a measure of the potential for a plan to also include benefits for ecosystem restoration, flood control, public safety, and hydropower with the lowest incidental and economically justified additional cost. All dam raise scenarios provide some amount of increased seasonal storage space that can contribute to increased efficiency in flood operations and a higher head for power generation. For public safety, all plans would include added features to increase the certainty of Shasta Dam and Reservoir safely passing the PMF. The relative efficiency of providing flood control and hydropower increases with larger reservoirs and higher dam raises. The efficiency of a plan in providing ecosystem restoration relative to enlarging Shasta Dam and Reservoir will require additional evaluation.

Likelihood for Federal Interest
Potential for Federal interest exists for each of the concept plans, providing the plans are economically feasible and a non-Federal sponsor(s) is capable and

willing to share in implementing the cost for a potential project. For those plans with high costs for a specific unit of benefit to the anadromous fishery, ecosystem, or water supply reliability, potential for Federal interest is greatly diminished because of the likely lack of economic feasibility. This is believed to be especially true for concept plans similar to AFS-1, AFS-2, AFS-3, WSR-3, and CO-3.

CALFED Consistency

This is a measure of the relationship of the plan to the overall goals and objectives of the CALFED Programmatic ROD, or other ongoing projects and programs. To rank high, a plan must neither preclude nor enhance the potential for development of other projects and programs. All of the concept plans, with the exception of AFS-1 and WSR-3, are believed to be fundamentally consistent with the CALFED Programmatic ROD.

Concept Alternatives Carried Forward

After comparing each concept plan to the planning criteria above, five plans initially appeared superior in Table 4-3 and in supporting analyses. Accordingly, these five plans and the required No-Action plan were recommended for further development in the comprehensive plans phase of the SLWRI. However, although WSR-4 was initially carried forward as an alternative, subsequent analysis of the conjunctive use component indicated tradeoffs between conjunctive use water supply benefits and critical gains in fisheries benefits. The resulting reduction in benefits to fisheries operations in dry and critical years was deemed unacceptable in terms of meeting primary project planning objectives. Thus, WSR-4 and the conjunctive use component of CO-5 were eliminated from further consideration. CO-2 was also initially carried forward, but was subsequently eliminated from further consideration because continued evaluation concluded that restoration of existing gravel mines would have a low likelihood of successfully benefiting salmon resources. Concept plans recommended for further development include the following:

- No-Action
- **WSR-1** –Increase Water Supply Reliability with Shasta Enlargement (6.5 feet)
- **WSR-2** – Increase Water Supply Reliability with Shasta Enlargement (18.5 feet)
- **CO-5** – Multipurpose with Shasta Enlargement (18.5 feet)

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Chapter 5
Comprehensive Plans

This chapter provides an overview of the five comprehensive plans, including a discussion of comprehensive plan formulation, management measures common to all comprehensive plans, major components of dam raise scenarios, and costs and benefits of each comprehensive plan. Also included is a general description of the No-Action Alternative and the five comprehensive plans. For each of the five comprehensive plans, major components, benefits, and primary effects are described.

Overview of Comprehensive Plans

The comprehensive plans in this EIS include the following:

- **Comprehensive Plan 1 (CP1) –** 6.5-foot dam raise, enlarging the reservoir by 256,000 acre-feet, focusing on both anadromous fish survival and water supply reliability.
- **Comprehensive Plan 2 (CP2)** – 12.5-foot dam raise, enlarging the reservoir by 443,000 acre-feet, focusing on both anadromous fish survival and water supply reliability.
- **Comprehensive Plan 3 (CP3)** – 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on both agricultural water supply reliability and anadromous fish survival.
- **Comprehensive Plan 4 (CP4) and Comprehensive Plan 4A (CP4A)** – 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on anadromous fish survival while increasing water supply reliability.
- **Comprehensive Plan 5 (CP5) –** 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, a combination plan focusing on all objectives.

Development and Refinement of Comprehensive Plans

Consistent with the P&G, the iterative plan formulation process included assessing and refining concept plans and management measures carried forward to formulate comprehensive plans. As described in Chapters 2 and 4, numerous management measures were identified, evaluated, and screened, and from them various initial plans were developed that encompass the scope of potential alternatives focused on addressing the planning objectives. Plans including the following attributes were identified for further development into comprehensive plans. Fundamentally, these plans consist of the following:

- Plan(s) to raise Shasta Dam between 6.5 feet and 18.5 feet, focusing on both water supply reliability and anadromous fish survival but with benefits to various secondary planning objectives

- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on increased anadromous fish survival but also including water supply reliability, and other secondary planning objectives

- Plan(s) to raise Shasta Dam by about 18.5 feet, focusing on all planning objectives

Considering results of initial plan formulation efforts, the approach was to first formulate plans focusing on different dam raise heights within the range of 6.5 feet to 18.5 feet to address the first plan type listed above. This is generally addressed by the first plan type listed above. A dam raise of 12.5 feet was chosen because it represented a midpoint between the smallest and largest practical dam raises. In addition, features were added to alternatives involving raising Shasta Dam to address maintaining or increasing recreation in the lake area. Next, the approach was to identify the most efficient and effective dam raise height and formulate comprehensive plans to focus on anadromous fish survival and other objectives at this height.

Comprehensive Plans in the Draft Feasibility Report and Supporting Documents

Using the general rationale described above, and incorporating input from the public scoping process and continued coordination with resource agencies and other interested parties, five comprehensive plans were developed for the Draft Feasibility Report and Preliminary DEIS:

- **Preliminary Comprehensive Plan 1 (PCP1) –** 6.5-foot dam raise, enlarging the reservoir by 256,000 acre-feet, focusing on both anadromous fish survival and water supply reliability.

- **Preliminary Comprehensive Plan 2 (PCP2) –** 12.5-foot dam raise, enlarging the reservoir by 443,000 acre-feet, focusing on both anadromous fish survival and water supply reliability.

- **Preliminary Comprehensive Plan 3 (PCP3) –** 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on both anadromous fish survival and water supply reliability.

- **Preliminary Comprehensive Plan 4 (PCP4) –** 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, focusing on anadromous fish survival while increasing water supply reliability.

- **Preliminary Comprehensive Plan 5 (PCP5) –** 18.5-foot dam raise, enlarging the reservoir by 634,000 acre-feet, a combination plan focusing on all objectives.

As described further in Chapter 3 of the EIS, Section 3.2.3, "Methods and Assumptions," due to uncertainty related to CVP and SWP operational constraints, water operations modeling and related evaluations in the 2011 Draft Feasibility Report and Preliminary DEIS were based on available modeling analyses at the time. This modeling reflected CVP and SWP operations and constraints described in:

- The Reclamation 2004 *Long-Term CVP and SWP Operations Criteria and Plan Biological Assessment* (2004 OCAP BA) (Reclamation 2004)

- The NMFS 2004 *Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan NMFS Biological Opinion* (2004 NMFS BO) (NMFS 2004)

- The USFWS 2005 *Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues* (2005 USFWS BO) (USFWS 2005)

These analyses were suitable for comparison purposes, and reflected expected variation among the alternatives, including the type and relative magnitude of anticipated impacts and benefits.

Because of the large number of possibilities for increasing anadromous fish survival, additional analyses were conducted to determine the combination of actions that would provide the greatest overall benefits within PCP4. These analyses are described below.

Refinement of Plan for Anadromous Fish Survival Focus with Water Supply Reliability

Primarily using the SALMOD model, and based on output from the water operations (CalSim-II), reservoir temperature, and river temperature models, a suite of flow-focused and temperature-focused actions (scenarios) were investigated to assess which combination of actions would likely result in the maximum increase in fish populations.

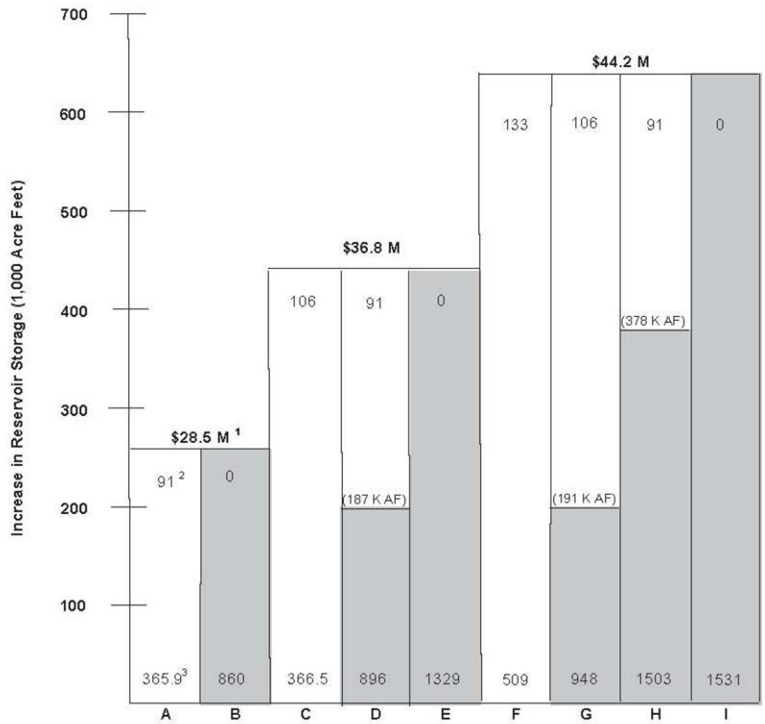
To formulate PCP4, three dam height raises were considered (6.5 feet, 12.5 feet, and 18.5 feet), resulting in 256,000 acre-feet, 443,000 acre-feet, and 634,000 acre-feet of increased storage, respectively. For each of these proposed dam raises, several combinations for allocating the increased storage were analyzed. For instance, assuming a dam raise of 12.5 feet, three options were considered: (1) no increase in the minimum pool, (2) an increase in the minimum pool similar to a 6.5-foot dam raise, and (3) all of the increased space dedicated to increased fisheries. The combinations considered represent scenarios developed to focus on increasing the cold-water pool, and are listed in Table 5-1. Figure 5-1 illustrates the various combinations considered. Included in the figure is information about cost (average annual), increased dry and critical year water supplies for CVP/SWP deliveries, and increased numbers of anadromous fish for the various combinations considered.

Table 5-1. Scenarios Considered for Cold-Water Storage as Part of Fish Focus Plan

Scenario	Dam Raise (feet)	Enlarged Reservoir	Description
A (PCP1)	6.5	256,000 acre-feet	No increase in minimum pool
B	6.5	256,000 acre-feet	Dedicating 256,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.
C (PCP2)	12.5	443,000 acre-feet	No increase in minimum pool
D	12.5	443,000 acre-feet	Dedicating 187,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
E	12.5	443,000 acre-feet	Dedicating 443,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.
F (PCP3/ PCP5)	18.5	634,000 acre-feet	No increase in minimum pool
G	18.5	634,000 acre-feet	Dedicating 191,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
H (PCP4)	18.5	634,000 acre-feet	Dedicating 378,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit.
I	18.5	634,000 acre-feet	Dedicating 634,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit.

Notes:
Water operations based on the Reclamation 2004 Long-Term CVP and SWP Operations Criteria and Plan Biological Assessment (2004 OCAP BA) (Reclamation 2004); the NMFS 2004 Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan NMFS Biological Opinion (2004 NMFS BO) (NMFS 2004); and the USFWS 2005 Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues

Key:
PCP1 = Preliminary Comprehensive Plan 1
PCP2 = Preliminary Comprehensive Plan 2
PCP3 = Preliminary Comprehensive Plan 3
PCP4 = Preliminary Comprehensive Plan 4
PCP5 = Preliminary Comprehensive Plan 5



Notes:

1 Average annual cost ($ millions).

2 Average annual increase in dry and critical year CVP/SWP deliveries (1,000 acre-feet per year).

3 Average annual increase in anadromous fish survival (1,000 fish).

Figure 5-1. Combinations Considered Between Increased Storage Dedicated to Either Water Supply Reliability or Increasing Cold-Water Supply for Fisheries

Additional scenarios focused on increasing Sacramento River flows with an 18.5-foot raise were also analyzed. The flow combinations were based primarily on flows identified as part of the Anadromous Fish Restoration Plan (USFWS 2001). These scenarios are listed in Table 5-2.

Table 5-2. Scenarios Considered to Augment Flows as Part of Fish Focus Plan

Scenario	Dam Raise (feet)	Enlarged Reservoir	Description
1	18.5	634,000 acre-feet	October - March Anadromous Fish Restoration Program flows or 500 cfs increase, whichever is lower
2	18.5	634,000 acre-feet	October - March Anadromous Fish Restoration Program flows or 750 cfs increase, whichever is lower
3	18.5	634,000 acre-feet	October - March Anadromous Fish Restoration Program flows or 1,000 cfs increase, whichever is lower
4	18.5	634,000 acre-feet	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control

Note:
Water operations based on the NMFS 2004 Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan NMFS Biological Opinion (2004 NMFS BO) (NMFS 2004); and the USFWS 2005 Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues
Key:
cfs = cubic feet per second

Quantitative analysis indicated that increasing the minimum pool in Shasta Reservoir would have the greatest net fishery benefit. By increasing the minimum pool, the allowable carryover pool storage in the reservoir would be increased. This carryover would act to conserve cold water that could be managed to better benefit anadromous fish. Scenarios 1, 2, 3, and 4 (flow augmentation scenarios) showed limited benefits to anadromous fish compared with other scenarios and were eliminated from further analysis.

As can be seen in Figure 5-1, Scenarios B, E, and I would not have contributed to increased water supply reliability. Even though PCP4 focused on anadromous fish survival, because these three concepts would not have contributed to the other primary planning objective of increasing water supply reliability, they were removed from further consideration. Table 5-3 compares the remaining scenarios. Each of the scenarios was assessed against the relative increase in fish production versus the remaining cost between water supply forgone for each scenario and the overall annual cost for the concept. Figure 5-2, is a plot of increased fish production versus remaining cost for each of the scenarios considered from Table 5-3. Included in the figure is an estimate of the “best buy” envelope. As indicated in the figure, Scenarios D and H appeared to be more cost-effective than the other scenarios because they were generally along the “best buy” envelope.

Table 5-3. Cost Effectiveness Screening for Efficiency of Annualized Preliminary Combined Scenarios

Water Supply Benefits					
Scenario	**Increase in Fish Production[1] (1,000)**	**Increased CVP/SWP Deliveries (1,000 acre-feet/ Year)[2]**	**Benefit ($1,000)[3]**	**Annual Costs ($1,000)**	**Remaining Costs ($1,000)**
NA	-	-	-	-	-
A (PCP1)	387	91	13,600	29,800	16,200
C (PCP2)	337	106	18,500	38,200	19,700
D	816	91	13,600	38,200	24,600
F (PCP3)	627	133	18,500	46,400	27,900
G	816	106	18,500	46,400	27,900
H (PCP4)	1,195	91	13,700	46,400	32,700

Notes:
[1] Derived using SALMOD
[2] Water operations based on the NMFS 2004 Biological Opinion on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan NMFS Biological Opinion (2004 NMFS BO) (NMFS 2004) and the USFWS 2005 Reinitiation of Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and the Operational Criteria and Plan to Address Potential Critical Habitat Issues
[3] See Economic Valuation Appendix for the Draft Feasibility Report.
Key:
- = not applicable
CVP = Central Valley Project
NA = No-Action Alternative
PCP1 = Preliminary Comprehensive Plan 1
PCP2 = Preliminary Comprehensive Plan 2
PCP3 = Preliminary Comprehensive Plan 3
PCP4 = Preliminary Comprehensive Plan 4
SWP = State Water Project

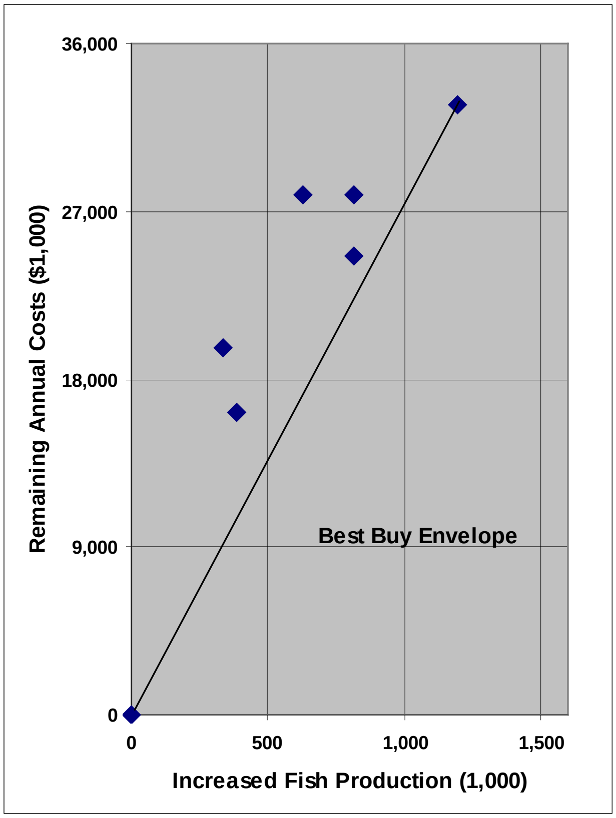


Figure 5-2. Cost-Effectiveness Assessment of Combined Scenarios

Based on numerical modeling results, Scenario H was chosen to represent reservoir operation in PCP4 because it provided the greatest benefit to anadromous fish while still meeting the primary objective of water supply reliability. Accordingly, PCP4 included raising Shasta Dam 18.5 feet and increasing the storage for cold-water supply in Shasta Reservoir by about 378,000 acre-feet.

Refinement of Comprehensive Plans for the DEIS and Final EIS

Comprehensive plans were further refined for the DEIS and Final EIS based on several factors, including updates to CVP and SWP water operations and stakeholder input. Since the release of the Draft Feasibility Report and Preliminary DEIS, water operations modeling in CalSim-II and related analyses for the SLWRI were updated to reflect the following:

- 2008 Long-Term Operation BA (Reclamation 2008)
- 2008 USFWS BO (USFWS 2008)
- 2009 NMFS BO (NMFS 2009)

- Additional changes in CVP and SWP facilities and operations, such as the enlarged Los Vaqueros Reservoir and implementation of the San Joaquin River Restoration Program

- Additional changes in non-CVP/SWP facilities and operations, such as the addition of the Freeport Regional Water Project

Preliminary analyses based on these updated operations indicated shifts in the distribution of water supply benefits from M&I to agricultural uses, resulting in decreased M&I water supply benefits for the Draft Feasibility Report comprehensive plans. Draft Feasibility Report comprehensive plans with updated water operations modeling are labeled with “No Storage Reserved for M&I” in Table 5-4.

To improve the balance between agricultural and M&I water supply benefits, refined scenarios were considered for comprehensive plans in which a portion of the increased storage capacity in Shasta Reservoir was reserved to specifically focus on increasing M&I deliveries. Table 5-4 highlights the range of scenarios considered and water supply reliability and fisheries benefits under each scenario. Based on resulting water supply and fisheries benefits under these scenarios, a portion of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries during dry and critical years under CP1, CP2, CP4, and CP5. Operations targeting increased M&I deliveries were based on existing and anticipated future demands, operational priorities, and facilities of the SWP, which provides M&I water to a majority of the State’s population.

In addition, to provide a greater range of focus and operations within the set of comprehensive plans, water supply operations for CP3 were focused on agricultural water supply reliability and anadromous fish survival. Accordingly, for CP3, none of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries.

Scenario Screening and Selection

This section describes scenarios selected for DEIS and Final EIS comprehensive plans along with rationale for scenario selection and screening. Comprehensive plans are described in more detail in the “Comprehensive Plans” section below.

Table 5-4. Scenarios Considered for Refinement of DEIS Comprehensive Plans

Item	CP1- No Storage Reserved for M&I	CP1- 70/35 M&I[2]	CP1- 100/50 M&I[3]	CP1- 120/60 M&I[4]	CP2- No Storage Reserved for M&I	CP2- 100/50 M&I[2]	CP2- 120/60 M&I[4]	CP2- 150/75 M&I[5]	CP3/CP5- No Storage Reserved for M&I	CP5- 120/60 M&I[4]	CP5- 150/75 M&I[5]	CP4- No Storage Reserved for M&I	CP4- 70/35 M&I[2]	CP4- 100/50 M&I[3]
Dam Raise Height (feet)	6.5	6.5	6.5	6.5	12.5	12.5	12.5	12.5	18.5	18.5	18.5	18.5	18.5	18.5
Increased CVP Water Supply Reliability[1]														
Average (AF/year)	32,400	16,300	12,400	8,300	45,400	29,300	26,900	18,700	69,900	52,000	47,600	32,400	16,300	12,400
Dry/Critical (AF/year)	45,400	13,700	8,600	2,400	53,900	29,000	24,700	14,600	85,300	63,800	55,200	45,400	13,700	8,600
Increased SWP Water Supply Reliability[1]														
Average (AF/year)	(4,300)	14,700	21,200	24,300	(1,600)	21,400	24,400	31,900	(8,200)	20,200	28,200	(4,300)	14,700	21,200
Dry/Critical (AF/year)	(13,500)	33,600	48,400	58,100	(7,600)	46,800	53,100	64,400	(22,200)	48,100	58,300	(13,500)	33,600	48,400
Increased Agricultural Water Supply Reliability[1]														
Average (AF/year)	29,600	20,300	18,200	14,400	42,200	33,400	31,400	25,900	62,200	52,500	50,900	29,600	20,300	18,200
Dry/Critical (AF/year)	38,700	22,500	21,900	18,600	48,400	41,100	37,600	31,200	70,600	70,800	66,100	38,700	22,500	21,900
Increased M&I Water Supply Reliability[1]														
Average (AF/year)	(1,600)	10,700	15,400	18,200	1,700	17,300	19,900	24,700	(500)	19,700	25,000	(1,600)	10,700	15,400
Dry/Critical (AF/year)	(6,800)	24,800	35,000	41,800	(2,200)	34,700	40,200	47,900	(7,500)	41,100	47,400	(6,800)	24,800	35,000
Total Increase in Water Supply Reliability[1]														
Average (AF/year)	28,000	31,000	33,700	32,600	43,900	50,700	51,300	50,600	61,700	72,200	75,900	28,000	31,000	33,700
Dry/Critical (AF/year)	31,900	47,300	57,000	60,500	46,200	75,800	77,800	79,100	63,100	111,900	113,500	31,900	47,300	57,000
Increased Anadromous Fish Survival														
Production Increase (number of fish)[6]	148,600	61,300	28,600	Not Modeled	295,300	285,800	379,200	311,600	207,400	Not Modeled	377,800	953,800	812,600	800,700

Notes:
[1] Increased water supply reliability was simulated with CalSim-II based on October to September water years.
[2] For this scenario, 70 TAF and 35 TAF of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.
[3] For this scenario, 100 TAF and 50 TAF of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.
[4] For this scenario, 120 TAF and 60 TAF of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.
[5] For this scenario, 150 TAF and 75 TAF of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.
[6] Average annual increase in juvenile Chinook salmon surviving to migrate downstream from Red Bluff Pumping Plant simulated using SALMOD. These estimates represent an index of production increase, based on the simulated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the RBPP.

Key:
AF = acre-feet
CP = Comprehensive Plan
CVP = Central Valley Project
M&I = municipal and industrial
SWP = State Water Project
TAF = thousand acre-feet

Comprehensive Plan 1 (CP1) – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability CP1 focuses on increasing anadromous fish survival and water supply reliability primarily through raising Shasta Dam by 6.5 feet, enlarging Shasta Reservoir by approximately 256,000 acre-feet.

CP1 Storage Reserved for Increasing M&I Deliveries As shown in Table 5-4, four operational scenarios were evaluated for CP1. The selected scenario includes reserving 70,000acre-feet and 35,000 acre-feet of the expanded storage capacity in Shasta Reservoir to specifically focus on increasing M&I deliveries during dry and critical years, respectively. This scenario is identified as "CP1-70/35 M&I" in Table 5-4.

Rationale for Screening and Selection The selected scenario contributes to both primary objectives through providing increased agricultural and M&I water supply reliability and increased anadromous fish survival. Scenarios that did not contribute to both primary objectives were deleted from further consideration for CP1. Of the remaining scenarios, CP1-70/35 M&I was selected because it allowed for improved balance between agricultural and M&I water supply benefits compared to other scenarios considered for CP1.

Comprehensive Plan 2 (CP2) – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability CP2 focuses on increasing anadromous fish survival and water supply reliability primarily through raising Shasta Dam by 12.5 feet, enlarging Shasta Reservoir by approximately 443,000 acre-feet.

CP2 Storage Reserved for Increasing M&I Deliveries As shown in Table 5-4, four operational scenarios were evaluated for CP2. The selected scenario includes reserving 120,000acre-feet and 60,000 acre-feet of the expanded storage in Shasta Reservoir to specifically focus on increasing M&I deliveries during dry and critical years, respectively. This scenario is identified as "CP2-120/60 M&I" in Table 5-4.

Rationale for Screening and Selection The selected scenario contributes to both primary objectives through providing increased agricultural and M&I water supply reliability and increased anadromous fish survival. Scenarios that did not contribute to both primary objectives were deleted from further consideration for CP2. Of the remaining scenarios, CP2-120/60 M&I was selected because it maximizes potential average year increases in water supply reliability and better balances agricultural and M&I water supply benefits compared to other scenarios considered for CP2.

Comprehensive Plan 3 (CP3) – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival CP3 focuses on increasing agricultural water supply reliability and anadromous fish survival primarily through raising Shasta Dam by 18.5 feet, enlarging Shasta Reservoir by approximately 634,000 acre-feet.

CP3 Storage Reserved for Increasing M&I Deliveries Because CP3 focuses on increasing agricultural water supply reliability and anadromous fish survival, none of the increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. This scenario is identified as “CP3-No Storage Reserved for M&I” in Table 5-4.

Rationale for Screening and Selection Scenario CP3-No Storage Reserved for M&I was selected because it maximizes potential agricultural water supply deliveries under a 6.5-foot to 18.5-foot raise of Shasta Dam. Since CP3 focuses on agricultural water supply reliability, scenarios reserving storage capacity for increasing M&I deliveries were deleted from further consideration.

Comprehensive Plan 4 (CP4) – 18.5-Foot Dam Raise, Anadromous Fish Survival Focus with Water Supply Reliability CP4 focuses on increasing anadromous fish survival, primarily through raising Shasta Dam by 18.5 feet and enlarging Shasta Reservoir by approximately 634,000 acre-feet, while also increasing water supply reliability.

CP4 Storage Reserved for Increasing M&I Deliveries As shown in Table 5-4, three operational scenarios were evaluated for CP4. Under CP4, approximately 378,000 acre-feet of the increased storage capacity would be dedicated to increasing the supply of cold water in Shasta Reservoir for anadromous fish survival purposes. For the selected scenario, operations for the remaining portion of the increased storage (approximately 256,000 acre-feet) would be the same as in CP1, with 70,000 acre-feet and 35,000 acre-feet of the expanded storage in Shasta Reservoir reserved to specifically focus on increasing M&I deliveries during dry and critical years, respectively. This scenario is identified as “CP4-70/35 M&I” in Table 5-4.

Rationale for Screening and Selection Scenario CP4-70/35 M&I was selected because it maximizes potential fisheries benefits while still increasing agricultural and M&I water supply reliability. Scenarios that did not contribute to both primary objectives were deleted from further consideration for CP4. CP4-70/35 M&I also allows for improved balance between agricultural and M&I water supply benefits compared to other scenarios considered for CP4 that contribute to both primary objectives.

Comprehensive Plan 5 (CP5) – 18.5-Foot Dam Raise, Combination Plan CP5 focuses on increased water supply reliability, anadromous fish survival, Shasta Lake area environmental resources, and increased recreation opportunities, primarily through raising Shasta Dam by 18.5 feet, enlarging Shasta Reservoir by approximately 634,000 acre-feet.

CP5 Storage Reserved for Increasing M&I Deliveries As shown in Table 5-4, three operational scenarios were evaluated for CP5. The selected scenario includes reserving 150,000acre-feet and 75,000 acre-feet of the expanded storage in Shasta Reservoir to specifically focus on increasing M&I deliveries during dry and critical years, respectively. This scenario is identified as “CP5-150/75 M&I” in Table 5-4.

Rationale for Screening and Selection The selected scenario contributes to both primary objectives through providing increased agricultural and M&I water supply reliability and increased anadromous fish survival. Scenarios that did not contribute to both primary objectives were deleted from further consideration for CP5. Of the remaining scenarios, CP5-150/75 M&I was selected because it maximizes both average year and dry and critical year increases in water supply reliability and better balances agricultural and M&I water supply benefits compared to other scenarios considered for CP5.

Refinement of Operational Scenario for Plan Focused on Anadromous Fish Survival with Water Supply Reliability Based on public comments on the Draft Feasibility and Draft EIS, a refined operational scenario (Comprehensive Plan 4A (CP4A)) was developed for the anadromous fish focus plan. This new operational scenario is a refinement of the operations for CP4, based on several factors, including the updated CVP and SWP operations, described above, which are based on the 2008 USFWS BO and 2009 NMFS BO. A suite of temperature and flow-focused actions (scenarios) were investigated to assess which combination of actions would likely maximize increases in anadromous fish populations. These investigations primarily used the SALMOD model, and were based on output from the water operations (CalSim-II), reservoir temperature, and river temperature models. Similar scenario refinements were considered for the Draft Feasibility Report, as summarized in Table 5-1 and Table 5-2. However, Draft Feasibility Report scenarios were based on CVP and SWP operational scenarios including the 2004 NMFS BO and 2005 USFWS BO, which have been since updated.

A range of scenarios were considered during the development of CP4A. For these scenarios, several combinations for allocating the increased storage were analyzed, focusing on either increasing the volume of the cold-water pool in Shasta Reservoir or augmenting flows downstream from Shasta Dam. Flow augmentation scenarios were based primarily on flows identified as part of the Anadromous Fish Restoration Plan (USFWS 2001). Table 5-5 highlights the range of scenarios considered and estimated benefits to water supply reliability and anadromous fisheries under each scenario.

Scenario G in Table 5-5 was selected as the refined operational scenario CP4A, as it allows for improved balance between water supply benefits and fisheries benefits compared to other scenarios.

Table 5-5. Scenarios Considered for Refinement of Final EIS Comprehensive Plans

Scenario	Dam Raise (feet)	Enlarged Reservoir (acre-feet)	Description	Production Increase (number of fish)[1]	Total Increase in Water Supply Reliability[2] Average (acre-feet/year)	Total Increase in Water Supply Reliability[2] Dry/Critical (AF/year)
Scenarios Considered for Cold-Water Storage as Part of Fish Focus Plan						
A (CP1)	6.5	256,000	No increase in minimum cold-water pool for fishery benefit. 70,000 acre-feet and 35,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively	61,300	31,000	47,300
B	6.5	256,000	Dedicate 256,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit. No increased storage capacity in Shasta Reservoir reserved for water supply.	673,000	0	0
C (CP2)	12.5	443,000	No increase in minimum cold-water pool for fishery benefit. 100,000 acre-feet and 50,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	379,200	51,300	77,800
D	12.5	443,000		428,700	31,000	47,300
E	12.5	443,000	Dedicate 443,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit. No increased storage capacity in Shasta Reservoir reserved for water supply.	999,900	0	0
F (CP3)	18.5	634,000	No increase in minimum cold-water pool for fishery benefit. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	207,400	61,700	63,100
F (CP5)	18.5	634,000	No increase in minimum cold-water pool for fishery benefit. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	377,800	75,900	113,500

Table 5-5. Scenarios Considered for Refinement of Final EIS Comprehensive Plans (contd.)

Scenario	Dam Raise (feet)	Enlarged Reservoir (acre-feet)	Description	Production Increase (number of fish)[1]	Total Increase in Water Supply Reliability[2] Average (acre-feet/year)	Total Increase in Water Supply Reliability[2] Dry/Critical (AF/year)
G (CP4A)	18.5	634,000	Dedicate 191,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit. 100,000 acre-feet and 50,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	710,000	51,300	77,800
H (CP4)	18.5	634,000	Dedicate 378,000 acre-feet of the additional water from increased storage to increase the size of the cold-water pool for fishery benefit. 70,000 acre-feet and 35,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	812,600	31,000	47,300
I	18.5	634,000	Dedicate 634,000 acre-feet of water from increased storage to increase the size of the cold-water pool for fishery benefit. No increased storage capacity in Shasta Reservoir reserved for water supply.	971,400	0	0
Scenarios Considered to Augment Flows as Part of Fish Focus Plan						
1[2]	18.5	634,000	October - March Anadromous Fish Restoration Program flows or 500 cfs increase, whichever is lower. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	348,700	54,600	57,200
1[3]	18.5	634,000	October - March Anadromous Fish Restoration Program flows or 500 cfs increase, whichever is lower. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	319,300	65,000	91,300
3[2]	18.5	634,000	October - March Anadromous Fish Restoration Program flows or 1,000 cfs increase, whichever is lower. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	222,800	42,200	35,700
3[3]	18.5	634,000	October - March Anadromous Fish Restoration Program flows or 1,000 cfs increase, whichever is lower. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	309,500	54,600	69,300

Table 5-5. Scenarios Considered for Refinement of Final EIS Comprehensive Plans (contd.)

Scenario	Dam Raise (feet)	Enlarged Reservoir (acre-feet)	Description	Production Increase (number of fish)[1]	Total Increase in Water Supply Reliability[2] Average (acre-feet/year)	Total Increase in Water Supply Reliability[2] Dry/Critical (AF/year)
4[2]	18.5	634,000	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control. Increased storage capacity in Shasta Reservoir dedicated to agricultural deliveries.	88,400	62,600	76,400
4[3]	18.5	634,000	Increase August flows to 10,000 cfs and September flows to 6,000 cfs for temperature control. 150,000 acre-feet and 75,000 acre-feet of the increased storage capacity in Shasta Reservoir was reserved for increasing M&I deliveries in dry and critical years, respectively.	63,900	73,000	122,800

Notes:

[1] Estimates of increased anadromous fish survival were based on simulations using the SALMOD model. These estimates represent an index of production increase, based on the simulated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the RBPP.

[2] Increased water supply reliability was simulated with CalSim-II based on October to September water years. Water Year Types Based on the Sacramento Valley Water Year Hydrologic Classification. Water operations based on the USFWS 2008 Formal ESA Consultation on the Proposed Coordinated Operations of the CVP and SWP (USFWS 2008) and NMFS 2009 BO and Conference Opinion on the Long-Term Operations of the CVP and SWP (NMFS 2009).

[2] Refined operational scenario based on CP3 distribution of water supply benefits

[3] Refined operational scenario based on CP5 distribution of water supply benefits

Key:
CP = Comprehensive Plan
M&I = municipal and industrial
SWP = State Water Project

The refined operational scenario, CP4A, is identical to CP4, except for operations of Shasta Dam and Reservoir. CP4 and CP4A have similar reservoir operations in that they each dedicate a portion of the new storage in Shasta Lake for fisheries purposes, however, the portion of this dedicated storage varies. Under CP4A, approximately 191,000 acre-feet of the increased 634,000 acre-feet storage capacity would be dedicated to increasing the supply of cold water in Shasta Reservoir for anadromous fish survival purposes. Operations for the remaining portion of the increased storage (approximately 443,000 acre-feet) would be the same as in CP2, with 120,000 acre-feet and 60,000 acre-feet of the expanded storage in Shasta Reservoir reserved to specifically focus on increasing M&I deliveries during dry and critical years, respectively.

No-Action Alternative

NEPA and CEQA require the analysis of a baseline alternative, representing a scenario in which the project is not implemented. For all Federal feasibility studies of potential water resources projects, the No-Action Alternative is intended to account for existing facilities, conditions, land uses, and reasonably foreseeable actions expected to occur in the study area. Reasonably foreseeable actions include actions with current authorization, secured funding for design and construction, and environmental permitting and compliance activities that are substantially complete.

Under CEQA, the No-Project Alternative is similar to NEPA's No-Action Alternative, but it involves the review of two scenarios: the existing condition baseline, which represents only current conditions at the time the Notice of Preparation is published, and "reasonably foreseeable" future conditions without the project (which is equivalent to the NEPA No-Action Alternative).

For the SLWRI, the No-Action/No-Project Alternative is based on CVP and SWP operational conditions described in the 2008 Long-Term Operation BA, and the BOs issued by USFWS and NMFS in 2008 and 2009, respectively. The No-Action Alternative also includes continued implementation of actions identified under the CVPIA. In addition, the No-Action Alternative includes key projects assumed to be in place and operating in the future, including the Freeport Regional Water Project, Delta Water Supply Project, South Bay Aqueduct Improvement and Enlargement Project, a functional equivalent of the Vernalis Adaptive Management Plan, full restoration flows under the San Joaquin River Restoration Program, and full implementation of the Grassland Bypass Project. The existing and future conditions for the SLWRI are further described in EIS Chapter 3, Section 3.2.3. In addition, Table 2-1 of the Modeling Appendix shows which actions were assumed to be part of the existing condition and the future condition (or No-Action /No-Project Alternative) in the SLWRI 2012 Version CalSim-II model.

The No-Action Alternative is considered to be the basis for comparison with potential action alternatives, consistent with NEPA and the P&G (WRC 1983) guidelines. Thus, if no proposed action is determined to be feasible, the No-Action Alternative is the default option.

Under the No-Action Alternative, the Federal Government would continue to implement reasonably foreseeable actions, as defined above, but would not take additional actions toward implementing a plan to raise Shasta Dam to help increase anadromous fish survival in the upper Sacramento River, nor help address the growing water supply and reliability issues in California. The following discussions highlight the consequences of implementing the No-Action Alternative, as they relate to the planning objectives of the SLWRI.

In addition to comparing the No-Action Alternative to potential action alternatives, the potential action alternatives were also compared to the existing condition baseline (as described above) in consideration of CEQA requirements.

The accompanying EIS Chapters 4 through 25 include detailed descriptions of existing reservoir area infrastructure and study area resource conditions. Anticipated future resources conditions in the study area are also characterized. Detailed information on the study area is contained in the EIS and supporting appendices.

Anadromous Fish Survival

Much has been done to address anadromous fish survival problems in the upper Sacramento River. Solutions have ranged from changes in the timing and magnitude of releases from Shasta Dam to constructing and operating the TCD at the dam. Actions also include site-specific projects, such as introducing spawning gravel to the Sacramento River and work to improve or restore spawning habitat in tributary streams. However, to increase anadromous fish survival and reduce the risk of extinction, further water temperature improvements are needed in the Sacramento River, especially in dry and critical years. Increased demand for water for urban, agricultural, and environmental uses is also expected to reduce the reliability of cold water for anadromous fish. Prolonged drought that depletes the cold-water pool in Shasta Reservoir could put populations of anadromous fish at risk of severe population decline or extirpation in the long-term (NMFS 2014). The risk associated with a prolonged drought is especially high in the Sacramento River, as Shasta Reservoir is operated to maintain only 1 year of carryover storage.

Under the No-Action Alternative, it is assumed that actions to protect fisheries and benefit aquatic environments would continue, including maintaining the TCD, ongoing spawning gravel augmentation programs, and satisfying other existing regulatory requirements.

Water Supply Reliability

Demands for water in the Central Valley and throughout California exceed available supplies, and the need for additional supplies is expected to grow. There is growing competition for limited system resources among various users and uses, including urban, agricultural, and environmental. Urban water demand and environmental water requirements have each increased, resulting in greater competition for limited water supplies. As mentioned, the population of California and the Central Valley is expected to increase by more than 60 and 130 percent above 2005 levels, respectively, by 2050 (California Department of Finance 2007). As these population increases occur, and are coupled with the need to maintain a healthy and vibrant industrial and agricultural economy, the demand for water would continue to significantly exceed available supplies. Competition for available water supplies would intensify as water demands increase to support this population growth.

Water conservation and reuse efforts are expected to substantially increase and forced conservation resulting from increasing water shortages would continue. In the past, during drought years, many water conservation measures have been implemented to reduce the effects of the drought. In the future, as more water use efficiency actions become necessary to help meet even average year demands, the impacts of droughts will be much more severe. Besides forced conservation, without developing cost-efficient new sources, the growing urban population would increasingly rely on shifting water supplies from such areas as agricultural production to satisfy M&I demands. In the urban sector, reduced supplies or increased supply uncertainty could cause water rates to increase as agencies seek to remedy supply shortfalls by implementing measures to reduce demand and/or augment supplies.

It is likely that with continued and deepening shortages in available water supplies, adverse economic and socioeconomic impacts would increase over time in the Central Valley and elsewhere in California. One example could include higher water costs, resulting in a further shift in agricultural production to areas outside California and/or outside the United States. Another example could include water supply shortages resulting in changes in land use patterns, loss and destruction of permanent crops, and/or decreased production of existing crops. In response to reduced water supplies, farmers may fallow fields, reducing agricultural productivity directly resulting in layoffs, reduced hours for agricultural employees, and increased unemployment in agricultural communities. Reduced water supplies and the resulting employment losses could also cause socioeconomic impacts in affected communities.

Under the No-Action Alternative, Shasta Dam would not be modified and the CVP would continue operating similarly to existing conditions. The No-Action Alternative would continue to meet water supply demands at levels similar to existing conditions, but would not be able to meet the expected increased demand in California.

Ecosystem Resources, Flood Management, Hydropower Generation, Recreation, and Water Quality

As opportunities arise, some efforts would likely continue to improve environmental conditions on tributaries to Shasta and along the upper Sacramento River. However, overall, future environmental-related conditions in these areas would likely be similar to existing conditions. The quantity, quality, diversity, and connectivity of riparian, wetland, and riverine habitats along the Sacramento River have been limited by confinement of the river systems by levees, reclamation of adjacent lands for framing, bank protection, channel stabilization, and land development.

Shasta Dam and Reservoir have greatly reduced flood damage along the Sacramento River. Shasta Dam and Reservoir were constructed at a total cost of about $36 million in 1936 (about $2 billion in 2014 dollars). Shasta Dam, in combination with the Sacramento River Flood Control Project, protects about 1 million people and over $60 billion in assets. However, residual risks to human life, health, and safety along the Sacramento River remain. Development in flood-prone areas has exposed the public to the risk of flooding. Storms producing peak flows, and volumes greater than the existing flood management system was designed for, can occur, and result in extensive flooding along the upper Sacramento River. Under the No-Action Alternative, the threat of flooding would continue, and may increase as population growth increases.

California's demand for electricity is expected to substantially increase in the future. Under the No-Action Alternative, no actions would be taken to help meet this growing demand.

As California's population continues to grow, demands would grow substantially for water-oriented recreation at and near the lakes, reservoirs, streams, and rivers of the Central Valley. This increase in demand will be especially pronounced at Shasta Lake.

To address the impact of water quality deterioration on the Sacramento River basin and Delta ecosystems and endangered and threatened fish populations, several environmental flow goals and objectives in the Central Valley (including the Delta) have been established through legal mandates aimed at maintaining and recovering endangered and threatened fish and wildlife, and protecting designated critical habitat. Despite these efforts, under the No-Action Alternative, these resources would continue to decline and ecosystems would continue to be impacted. In addition, Delta water quality may continue to decline.

Comprehensive Plans

The following sections describe the comprehensive plans developed as action alternatives for the SLWRI. Management measures and environmental commitments common to all comprehensive plans are described first, followed by descriptions of major components, potential benefits, and potential primary effects for each comprehensive plan.

Management Measures Common to All Comprehensive Plans

Eight of the management measures retained in the alternatives development process (see Chapter 2) are included, to some degree, in all of the comprehensive plans. These measures were included because they (1) would either be incorporated or required with any dam raise, (2) were logical and convenient additions that would significantly improve any alternative, or (3) should be considered with any new water increment developed in California. The eight measures include (1) enlarging the Shasta Lake cold-water pool, (2) modifying the TCD, (3) increasing conservation storage, (4) reducing demand, (5) modifying flood operations, (6) modifying hydropower facilities, (7) maintaining or increasing recreation opportunities, (8) and maintaining or improving water quality.

Enlarge Shasta Lake Cold-Water Pool

Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBPP. At a minimum, all comprehensive plans would include enlarging the cold-water pool by raising Shasta Dam to enlarge Shasta Reservoir. Some alternatives would also increase the seasonal carryover storage in Shasta Lake.

Modify Temperature Control Device

For all comprehensive plans, the TCD would be modified to account for an increased dam height and to reduce leakage of warm water into the structure. Minimum modifications to the TCD include raising the existing structure and modifying the shutter control. This measure would increase the ability of operators at Shasta Dam to meet downstream temperature requirements, and provide more operational flexibility to achieve desirable water temperatures during critical periods for anadromous fish.

Increase Conservation Storage

All comprehensive plans would include increasing the amount of space available for water conservation storage in Shasta Reservoir by raising Shasta Dam. Conservation storage is the portion of the capacity of the reservoir available to store water for subsequent release to increase water supply reliability for M&I, agricultural, and environmental purposes. All comprehensive plans would include a range of dam enlargements and various increases in conservation space.

Reduce Demand

All comprehensive plans would include an additional water conservation program for increased water deliveries that would be created by the project to augment current water use efficiency practices. The proposed program would consist of a 10-year initial program in which Reclamation would allocate approximately $1.6 million to $3.8 million, proportional to additional water supplies delivered, to fund water conservation efforts. Funding would focus on assisting project beneficiaries (agencies receiving increased water supplies because of the project), with developing new or expanded urban water conservation, agricultural water conservation, and water recycling programs. Program actions would be a combination of technical assistance, grants, and loans to support a variety of water conservation projects such as recycled wastewater projects, irrigation system retrofits, and urban utilities retrofit and replacement programs. Reclamation, in collaboration with project beneficiaries, would identify and develop water conservation projects for funding under the program. Reclamation would then implement an investment strategy, in coordination with project beneficiaries, to identify and prioritize projects which, in conjunction with other water conservation activities, would cost-effectively reduce water demand and increase water conservation. This process would result in developing, evaluating, and prioritizing projects for funding. The program could be established as an extension of existing Reclamation programs, or as a new program, through teaming with cost-sharing partners. Combinations and types of water use efficiency actions funded would be tailored to meet the needs of identified cost-sharing partners, including consideration of cost-effectiveness at a regional scale for agencies receiving funding.

Modify Flood Operations

Potential modification of flood operations would be considered for all comprehensive plans. Enlargement of Shasta Reservoir would require alterations to existing flood operation guidelines or rule curves, to reflect physical modifications, such as an increase in dam/spillway elevation. The rule curves would be revised with the goal of reducing flood damage and enhancing other objectives to the extent possible.

Modify Hydropower Facilities

Under each comprehensive plan, enlargement of Shasta Dam would likely require various minimum modifications, commensurate with the magnitude of the enlargement, to the existing hydropower facilities at the dam to enable their continued efficient use. These modifications, in conjunction with increased lake surface elevations, may provide incidental benefits to hydropower generation. Although modifications could also be included to further increase the power production capabilities of the reservoir (e.g., additional penstocks and generators), they are believed to be a detail beyond the scope of this investigation and are not considered further at this level of planning.

Maintain and Increase Recreation Opportunities

In addition to the measures described above, all comprehensive plans would address, to some extent, the secondary planning objective of maintaining and increasing recreation opportunities at Shasta Lake. Outdoor recreation, and especially recreation at Shasta Lake, represents a major source of enjoyment to millions of people annually and is a major source of income to the northern

Sacramento Valley. Shasta Dam and Reservoir are within the Shasta Unit of the Whiskeytown-Shasta-Trinity NRA. Recreation within these lands is managed by USFS. As part of this administration, USFS either directly operates and maintains, or manages through leases, numerous public campgrounds, marinas, boat launching facilities, and related water-oriented recreation facilities. Enlarging Shasta Dam and Reservoir would affect some of these facilities. Consistent with the position of USFS, and planning conditions described in this chapter, all of the comprehensive plans would include features to, at a minimum, maintain the overall recreation capacity of the existing facilities. All comprehensive plans would also provide for modernization of relocated recreation facilities, including, at a minimum, modifications to comply with current standards for health and safety.

Maintain or Improve Water Quality

All alternatives could contribute to improved Delta water quality conditions and Delta emergency response. Additional storage in Shasta Reservoir would provide improved operational flexibility. Shasta Dam has the ability to provide increased releases and high flow releases to improve Delta water quality. Improved Delta water quality conditions could provide benefits for both water supply reliability and ecosystem restoration by potentially increasing Delta outflow during drought years and reducing salinity during critical periods.

Environmental Commitments Common to All Comprehensive Plans

Reclamation and/or its contractors would incorporate certain environmental commitments and best management practices (BMP) into any plan identified for implementation to avoid or minimize potential impacts. Reclamation would also coordinate planning, engineering, design and construction, operation, and maintenance phases of any authorized project modifications with applicable resource agencies.

The following environmental commitments would be incorporated into any action alternative for any project-related construction activities. This section does not include mitigation measures. A comprehensive mitigation strategy to mitigate potential effects of comprehensive plans is included in the EIS in the Preliminary Environmental Commitments and Mitigation Plan Appendix.

Develop and Implement Construction Management Plan

Reclamation would develop and implement a construction management plan to avoid or minimize potential impacts on public health and safety during project construction, to the extent feasible. The construction management plan would inform contractors and subcontractors of work hours, modes and locations of transportation and parking for construction workers; location of overhead and underground utilities; worker health and safety requirements; truck routes; stockpiling and staging procedures; public access routes; terms and conditions of all required project permits and approvals; and emergency response services contact information.

The construction management plan would also include construction notification procedures for the police, public works, and fire departments in the area where construction would occur. In addition, the construction management plan would include similar procedures for Federal and State agencies with similar jurisdictions, including USFS. Notices would also be distributed to neighboring property owners. The health and safety component of the construction management plan would be monitored for the implementation of the plan on a day-to-day basis by a Certified Industrial Hygienist.

The construction management plan would include effort to notify businesses, residents, and visitors associated with recreation activities on and surrounding Shasta Lake. In addition to information available at the Shasta Lake Visitors Center, informational signs and booths would be placed at key locations to be identified by Reclamation in conjunction with agencies and local business organizations. Reclamation will also develop and maintain a project-specific website that will be used for a wide range of informational purposes.

Comply with Permit Terms and Conditions

If any action alternative is approved and authorized for construction, Reclamation would require its contractors and suppliers, its general contractor, and all of the general contractor's subcontractors and suppliers to comply with all of the terms and conditions of all required project permits, approvals, and conditions attached thereto. If necessary, additional information (e.g., detailed designs and additional documentation) would be prepared and provided for review by decision makers and the public. Reclamation would ultimately be responsible for the actions of its contractors in complying with permit conditions. Compliance with applicable laws, policies, and plans for this project is discussed in Section 26.6 of this EIS.

Provide Relocation Assistance through Federal Relocation Assistance Program

All Federal, State, and local government agencies, and others receiving Federal financial assistance for public programs and projects that require the acquisition of real property must comply with the policies and provisions set forth in the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, as amended (Uniform Act) (Title 49, CFR, Part 24). All relocation and property acquisition activities would be performed in compliance with the Uniform Act. Any individual, family, or business displaced by implementation of any of the action alternatives would be offered relocation assistance services for the purpose of locating a suitable replacement property, to the extent consistent with the Uniform Act.

Under the Uniform Act, relocation services for residences would include providing a determination of the housing needs and desires, a list of comparable properties, transportation to inspect housing referrals, and reimbursement of moving costs and related expenses. For business relocation activities, relocation services would include providing a determination of the relocation needs and requirements; a determination of the need for outside specialists to plan, move, and reinstall personal property; advice as to possible sources of funding and assistance from other local, State, and Federal agencies; listings of commercial properties, and reimbursement for costs incurred in relocating and reestablishing the business. No relocation payment received would be considered as income for the purpose of the Internal Revenue Code.

Remain Consistent with USFS Built Environment Image Guide

Any facilities subject to USFS authorization that are constructed or reconstructed facilities would be consistent with USFS Built Environment Image Guide. The architectural character of facilities on National Forest System lands would be constructed using materials and design that keep with the visual and cultural identity of the landscape in which they are constructed. Reclamation would seek to maintain the quality of visitor experiences, affected facilities capacity will be replaced with facilities providing equivalent visual resource quality and amenities.

Protect Public Land Survey System Monuments and Property Corners

Reclamation would identify Public Land Survey System (PLSS) monuments or survey property corners affected by either inundation due to increased lake levels or construction activities. Reclamation or its contractors would protect all PLSS monuments and associated references and all property corners, either by positioning, or, where necessary, creating new references. The results will be filed with BLM and Shasta County.

Evaluate and Protect Paleontological Resources Discovered During Construction

If paleontological resources are discovered during construction activities, all work in the immediate vicinity of the discovery will stop immediately and Reclamation will be notified (as applicable). A qualified paleontologist will be retained to evaluate the find and recommend appropriate conservation measures, such as data recovery or protection in place. The conservation measures will be implemented before re-initiation of activities in the immediate vicinity of the discovery.

Develop and Implement Stormwater Pollution Prevention Plan

Any project authorized for construction would be subject to the construction-related stormwater permit requirements of the CWA National Pollutant Discharge Elimination System program. Reclamation would obtain any required permits through the Central Valley Regional Water Quality Control Board before any ground-disturbing construction activity. According to the requirements of Section 402 of the CWA, Reclamation and/or its contractors would prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) before construction, identifying BMPs to prevent or minimize erosion and the discharge of sediments and other contaminants with the potential to affect beneficial uses of or lead to violations of water quality objectives for surface waters. The SWPPP would include site-specific structural and operational

BMPs to prevent and control impacts on runoff quality, and procedures to be followed before each storm event. BMPs would control short-term and long-term erosion and sedimentation effects and stabilize soils and vegetation in areas affected by construction activities. The SWPPP would contain a site map that shows the construction site perimeter, existing and proposed buildings, lots, roadways, and stormwater collection and discharge points; drainage patterns across the project; and general topography both before and after construction. Additionally, the SWPPP would contain a visual monitoring program, a chemical monitoring program for "non-visible" pollutants that would be implemented if a BMP fails, and a sediment monitoring plan to be implemented if a particular site discharges directly to a water body listed on the CWA 303(d) list for sediment. BMPs for the project could include, but would not be limited to, silt fencing, straw bale barriers, fiber rolls, storm drain inlet protection, hydraulic mulch, and stabilized construction entrances.

Develop and Implement Erosion and Sediment Control Plan Reclamation would prepare and implement an erosion and sediment control plan to control short-term and long-term erosion and sedimentation effects, and to stabilize soils and vegetation in areas affected by construction activities. The plan would include all of the necessary local jurisdiction requirements regarding erosion control, and would implement BMPs for erosion and sediment control, as required. Types of BMPs may include, but would not be limited to, earth dikes and drainage swales, stream bank stabilization, and use of silt fencing, sediment basins, fiber rolls, and sandbag barriers.

Develop and Implement Feasible Spill Prevention and Hazardous Materials Management As part of the SWPPP, Reclamation and/or its contractors would develop and implement a spill prevention and control plan to minimize effects from spills of hazardous, toxic, or petroleum substances for project-related construction activities occurring in or near waterways. The accidental release of chemicals, fuels, lubricants, and nonstorm drainage water into water bodies would be prevented to the extent feasible. Spill prevention kits would always be close by when hazardous materials would be used (e.g., crew trucks and other logical locations). Feasible efforts would be implemented so that hazardous materials would be properly handled and the quality of aquatic resources would be protected by all reasonable means during work in or near any waterway. No fueling would be done within the ordinary high-water mark, immediate floodplain, or full pool inundation area, unless equipment stationed in these locations could not be readily relocated. Any equipment that could be readily moved out of the water body would not be fueled in the water body or immediate floodplain. For all fueling of stationary equipment done at the construction site, containments would be installed so that any spill would not enter the water, contaminate sediments that may come in contact with the water, or damage wetland or riparian vegetation. Any equipment that could be readily moved out of the water body would not be serviced within the ordinary high-water mark or immediate floodplain.

Additional BMPs designed to avoid spills from construction equipment and subsequent contamination of waterways would also be implemented. These could include, but would not be limited to, the following:

- Storage of hazardous materials in double-containment and, if possible, under a roof or other enclosure.
- Disposal of all hazardous and nonhazardous products in a proper manner.
- Monitoring of on-site vehicles for fluid leaks and regular maintenance to reduce the chance of leakage.
- Containment (using a prefabricated temporary containment mat, a temporary earthen berm, or other feature can provide containment) of bulk storage tanks.

Haulers delivering materials to the project site would be required to comply with regulations on the transport of hazardous materials codified in Title 49, CFR Part 173; Title 49, CFR Part 177; and Title 26, California Code of Regulations (CCR) Division 6. These regulations provide specific packaging requirements, define unacceptable hazardous materials shipments, and prescribe safe-transit practices, including route restrictions, by carriers of hazardous materials.

Water Quality Protection for In-River Construction

The efforts discussed below would be implemented to minimize potential adverse effects to water quality.

Implement In-River Construction Work Windows All construction activities along the Sacramento River would be conducted during months when instream flows were managed outside the flood season (e.g., June to September). In-river work between Keswick Dam and the RBPP would be conducted to minimize impacts to Sacramento River winter-run Chinook salmon (i.e., mid-August through September).

Comply with All Water Quality Permits and Regulations Project activities would be conducted to comply with all additional requirements specified in permits relating to water quality protection. Relevant permits anticipated to be obtained for the proposed action include a CWA Section 401 certification, and CWA Section 404 compliance through the USACE.

Implement Water Quality Best Management Practices BMPs that would be implemented to avoid and/or minimize potential impacts associated with construction and the 10-year-long spawning gravel augmentation program are described below.

Handle Spawning Gravel to Minimize Potential Water Quality Impacts Gravel would be sorted and transported in a manner that minimizes potential water quality impacts (e.g., management of fine sediments). Gravel would be washed at least once and have a cleanliness value of 85 or higher based on California Department of Transportation (Caltrans) Test No. 227. Gravel would also be completely free of oils, clay, debris, and organic material.

Minimize Potential Impacts Associated with Equipment Contaminants For in-river work, all equipment would be steam-cleaned every day to remove hazardous materials before the equipment entered the water. Biodegradable hydrocarbon products would be used in the heavy equipment in the stream channel.

Implement Feasible Spill Prevention and Hazardous Materials Management The accidental release of chemicals, fuels, lubricants, and non-storm drainage water into channels would be prevented to the extent feasible. Spill prevention kits would always be in close proximity when using hazardous materials (e.g., crew trucks and other logical locations). Feasible efforts would be implemented to ensure that hazardous materials are properly handled and the quality of aquatic resources is protected by all reasonable means. No fueling would be done within the ordinary high-water mark or immediate floodplain, unless equipment stationed in these locations was not readily relocated (i.e., pumps, generators). For stationary equipment that must be fueled on site, containments would be provided in such a manner that any accidental spill of fuel would not be able to enter the water or contaminate sediments that could come in contact with water. Any equipment that was readily moved out of the channel would not be fueled in the channel or immediate floodplain. All fueling done at the construction site would provide containment to the degree that any spill would be unable to enter the channel or damage wetland or riparian vegetation. No equipment servicing would be done within the ordinary high-water mark or immediate floodplain, unless equipment stationed in these locations could not be readily relocated (i.e., pumps, generators). Additional BMPs designed to avoid spills from construction equipment and subsequent contamination of waterways would also be implemented.

Minimize Potential Impacts Associated with Access and Staging Existing access roads would be used to the extent possible. Equipment staging areas would be located outside of the Sacramento River ordinary high water mark or the Shasta Dam full pool inundation area, and away from sensitive resources.

Remove Temporary Fills as Appropriate Temporary fill for access, side channel diversions, and/or side channel cofferdams, would be completely removed after completion of construction.

Remove Equipment from River Overnight and During High Flows Construction contractors would remove all equipment from the river on a daily basis at the end of the workday. Construction contractors would also monitor

Reclamation's Central Valley Operations Office Web site daily for forecasted flows posted there to determine and anticipate any potential changes in releases. If flows were anticipated to inundate a work area that would normally be dry, the contractor would immediately remove all equipment from the work area.

Extend and Enhance Existing Fish Habitat Structures in Shasta Lake

Reclamation and USFS, in conjunction with resource management agencies would identify areas at appropriate elevations to replace, extend, and enhance existing structural fish habitat. The structures would be installed concurrently with construction activities in the vicinity of construction sites or at locations identified by resource agencies. These activities would include maintaining shallow water and transitional riverine habitat with the placement of manzanita brush structures, large woody debris, and rock-boulder clusters. To the extent feasible, vegetation cleared for construction and borrow pit areas would be used to extend and enhance fish habitat structures. Excess vegetative materials cleared from construction and borrow pit areas would be stockpiled for future fish habitat enhancement. Additionally, areas within the enlarged reservoir having appropriate conditions to establish living plants, including willow (Salix sp.), buttonbush (*Cephalanthus* sp.), and cottonwood (*Populus* sp.), would be identified for the purposes of providing structural fish habitat when the established plants are inundated.

Fisheries Conservation

The efforts discussed below would be implemented to minimize potential adverse effects on fish species.

Implement In-Water Construction Work Windows Reclamation would identify and implement feasible in-water construction work windows in consultation with NMFS, USFWS, and CDFW. In-water work windows would be timed to occur when sensitive fish species were not present or would be least susceptible to disturbance.

Monitor Construction Activities A qualified biologist would monitor potential impacts to important fishery resources throughout all phases of project construction. Monitoring may not be necessary during the entire duration of the project if, based on the monitor's professional judgment (and with concurrence from Reclamation), a designated on-site contractor would suffice to monitor such activities and would agree to notify a biologist if aquatic organisms are in danger of harm. However, the qualified biologist would need to be available by phone and Internet and be able to respond promptly to any problems that arose.

Perform Fish Rescue/Salvage If spawning activities for sensitive fish species were encountered during construction activities, the biologist would be authorized to stop construction activities until appropriate corrective activities were completed or it was determined that the fish would not be harmed.

A qualified biologist would identify any fish species that may be affected by the project. The biologist would facilitate rescue and salvage of fish and other aquatic organisms that become entrapped within construction structures and cofferdam enclosures in the construction area. Any rescue, salvage, and handling of listed species would be conducted under appropriate authorization (i.e., incidental take statement/permit for the project, Federal Endangered Species Act Section 4(d) scientific collection take permit, or a Memorandum of Understanding).

If fish were identified as threatened with entrapment in construction structures, construction would be stopped and efforts made to allow fish to leave the project area before resuming work. If fish were unable to leave the project area of their own volition, then fish would be collected and released outside the work area. Fish entrapped in cofferdam enclosures would be rescued and salvaged before the cofferdam area was completely dewatered. Appropriately sized fish screens would be installed on the suction side of any pumps used to dewater in-water enclosures.

Reporting A qualified biologist would prepare a letter report detailing the methodologies used and the findings of fish monitoring and rescue efforts. Monitoring logs would be maintained and provided, with monitoring reports. The reports would contain, but not be limited to, the following: summary of activities; methodology for fish capture and release; table with dates, numbers, and species captured and released; photographs of the enclosure structure and project site conditions affecting fish; and recommendations for limiting impacts during subsequent construction phases, if appropriate.

Survey and Monitor Fish Migration between Shasta Lake and Squaw Creek

Reclamation would fund and implement an adaptive management effort to survey and monitor fish migration between Shasta Lake and Squaw Creek, within and immediately upstream from the new inundation zone, before and immediately after project completion, to determine if warm-water fish (bass) actively migrated into and cause adverse effects on native fish, amphibians, and mollusks. These study and monitoring activities would be warranted due to uncertainties associated with the potential for warm-water fish accessing tributary stream reaches currently isolated by passage barriers near the head of the existing reservoir. The surveys would document occurrences and abundances of warm-water fish species and USFS special-status species in lower Squaw Creek before and immediately after project completion to evaluate if reservoir enlargement coincides with increases in warm-water predator species and declines of special-status indicator species. If warm-water fish abundance increases or adverse effects attributed to warm-water fish predation on native fish, amphibians or mollusks is documented within 3-5 years after the project was completed, a fish barrier or other acceptable feature would be implemented to prevent or minimize further invasions and colonization by warm-water fish.

Revegetation Plan

Reclamation, in conjunction with cooperating agencies and private landowners, would prepare a comprehensive revegetation plan to be implemented in conjunction with other management plans (e.g., SWPPP). This plan would apply to any area included as part of an action alternative, such as inundation, relocation, or mitigation activities. Overall objectives of the revegetation plan would be to reestablish native vegetation to control erosion, provide effective ground cover, minimize opportunities for nonnative plant species to establish or expand, and provide habitat diversity over time. Reclamation would work closely with cooperating agencies, private landowners, and revegetation specialists to develop the sources of native vegetation, site-specific planting patterns and species assemblages necessary for a revegetation effort of this magnitude.

Invasive Species Management

Reclamation would develop and implement a control plan to prevent the introduction of zebra/quagga mussels, invasive plants, and other invasive species to project areas. The control plan would cover all workers, vehicles, watercraft, and equipment (both land and aquatic) that would come into contact with Shasta Reservoir, the shoreline of Shasta Reservoir, the Sacramento River, and any riverbanks, floodplains, or riparian areas. Plan activities could include, but would not be limited to, the following:

- Preinspection and cleaning of all construction vehicles, watercraft, and equipment before being shipped to project areas
- Reinspection of all construction vehicles, watercraft, and equipment on arrival at project areas
- Inspection and cleaning of all personnel before work in project areas

All inspections would be conducted by trained personnel and would include both visual and hands-on inspection methods of all vehicle and equipment surfaces, up to and including internal surfaces that have contacted raw water.

Approved cleaning methods would include a combination of the following:

- **Precleaning –** Draining, brushing, vacuuming, high-pressure water treatment, thermal treatment
- **Cleaning –** Freezing, desiccation, thermal treatment, high-pressure water treatment, chemical treatment

On-site cleanings would require capture, treatment, and/or disposal of any and all water needed to conduct cleaning activities.

Fire Protection and Prevention Plan

Reclamation would prepare and implement a fire protection and prevention plan to minimize the risk of wildfire or threat to workers, property, and the public. The USFS will maintain a plan similar to this Fire Protection and Prevention Plan which addresses preventing and controlling wildfires in the NRA as described by the interagency agreement with the California Department of Forestry and Fire Protection (CAL FIRE) and other associated entities. Reclamation's contractors would follow relevant safety standards/procedures related to fire prevention would be incorporated into the project design, and would be used during construction activities and project operation and maintenance. Safety standards and procedures include the California Building Code; the Shasta County Fire Plan; USFS safety requirements regarding fire hazards; CAL FIRE requirements for private lands; and California Public Utilities Code General Order 95, which provides procedures for proper removal, disposal, and placement of poles, wires, and associated infrastructure; and the National Electric Safety Code (a voluntary code that provides safety procedures for electric utility installation and operation). Precautionary activities to prevent construction-related fires wouldl include locating utilities a safe distance from vegetation and structures, proper construction of power lines, and construction worker safety training. Postconstruction infrastructure operation and maintenance would follow current safety practices associated with fire prevention and would include clearing vegetation from power utility facilities and other sources using combustion engines (e.g., water pumps) on a regular basis.

Construction Material Disposal

Reclamation's contractors would recycle or reuse demolished materials, such as steel or copper wire, concrete, asphalt, and reinforcing steel, as required and where practical. Other demolished materials would be disposed of in local or other identified permitted landfills in compliance with applicable requirements.

To reduce the risk to construction workers, the public, and the environment associated with exposure to hazardous materials and waste, Reclamation would implement the following:

- A Hazardous Materials Business Plan (HMBP) would be developed and implemented to provide information regarding hazardous materials to be used for project implementation and hazardous waste that would be generated. The HMBP would also define employee training, use of protective equipment, and other procedures that provide an adequate basis for proper handling of hazardous materials to limit the potential for accidental releases of and exposure to hazardous materials. All procedures for handling hazardous materials would comply with all Federal, State, and local regulations.

- Soil to be disposed of at a landfill or recycling facility would be transported by a licensed waste hauler.

- All relevant available asbestos survey and abatement reports and supplemental asbestos surveys would be reviewed. Removal and disposal of asbestos-containing materials would be performed in accordance with applicable Federal, State, and local regulations.

- A lead-based paint survey would be conducted to determine areas where lead-based paint is present and the possible need for abatement before construction.

Asphalt Removal

Per California Fish and Game Code 5650 Section (a), all asphaltic roadways and parking lots inundated by project implementation would be demolished and removed according to Shasta County standards. Asphalt would be disposed of at an approved and permitted waste facility. Dirt roads inundated by project implementation would remain in place.

The environmental commitment section of the DEIS included a commitment to develop and implement a comprehensive mitigation strategy to minimize potential impacts to physical, biological, and socioeconomic resources described in the DEIS. In conjunction with an interagency, interdisciplinary team, Reclamation refined and enhanced the mitigation measures, including development of a framework to quantify impacts (where appropriate) and establish mitigation ratios that were applicable to a number of impacts related to biological resources. The result of the development of a comprehensive mitigation strategy is documented in the Preliminary Environmental Commitments and Mitigation Plan (an appendix to this EIS).

Major Components of Comprehensive Plans

Three dam raise options were considered for the comprehensive plans, including 6.5-foot, 12.5-foot, and 18.5-foot raises. Other raise options up to 18.5 feet are possible; however, it is believed that the above three adequately represent the extent of benefits, effects, and costs associated with any raise within the range considered for this feasibility study. Table 5-6 summarizes the physical features associated with the comprehensive plans. Figure 5-3 illustrates major features in the Shasta Lake area common to all comprehensive plans.

Table 5-6. Summary of Physical Features of Comprehensive Plans

Main Features	Comprehensive Plans					
	CP1	CP2	CP3	CP4	CP4A	CP5
Dam and Appurtenant Structures						
Shasta Dam						
Crest Raise (feet)	6.5	12.5	18.5	18.5	18.5	18.5
Full Pool Height Increase (feet)	8.5	14.5	20.5	20.5	20.5	20.5
Elevation of Dam Crest (feet)1	1084.0	1090.0	1096.0	1096.0	1096.0	1096.0
Elevation of Full Pool (feet)2	1,078.2	1,084.2	1,090.2	1,090.2	1,090.2	1,090.2
Capacity Increase (acre-feet)	256,000	443,000	634,000	634,000	634,000	634,000
Main Dam	Raise dam crest. Construct new parapets and utility gallery. Raise existing elevator tower and hoist tower.	Raise dam crest. Construct new parapets and utility gallery. Raise existing elevator tower and hoist tower.	Raise dam crest. Construct new parapets and utility gallery. Raise existing elevator tower and hoist tower.	Raise dam crest. Construct new parapets and utility gallery. Raise existing elevator tower and hoist tower.	Raise dam crest. Construct new parapets and utility gallery. Raise existing elevator tower and hoist tower.	Raise dam crest. Construct new parapets and utility gallery. Raise existing elevator tower and hoist tower.
Wing Dams	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.	Raise to meet dam crest. Build new visitor center along left wing dam. Relocate gantry crane on right wing dam.
Spillway	Raise crest and extend piers. Replace 3 drum gates with 6 sloping fixed-wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping fixed-wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping fixed-wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping fixed-wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping fixed-wheel gates.	Raise crest and extend piers. Replace 3 drum gates with 6 sloping fixed-wheel gates.
River Outlets	Replace 4 lower-tier tube valves with jet flow gates.	Replace 4 lower-tier tube valves with jet flow gates.	Replace 4 lower-tier tube valves with jet flow gates.	Replace 4 lower-tier tube valves with jet flow gates.	Replace 4 lower-tier tube valves with jet flow gates.	Replace 4 lower-tier tube valves with jet flow gates.
Temperature Control Device	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.	Raise/modify controls.
Shasta Powerplant/ Penstocks	Raise penstock hoists.	Raise penstock hoists.	Raise penstock hoists.	Raise penstock hoists.	Raise penstock hoists.	Raise penstock hoists.

Table 5-6. Summary of Physical Features of Comprehensive Plans (contd.)

Main Features	Comprehensive Plans					
	CP1	CP2	CP3	CP4	CP4A	CP5
Pit 7 Dam/Powerhouse	Increase height of training walls on dam spillway. Install a tailwater depression system. Modify other Pit 7ancillary facilities.	Increase height of training walls on dam spillway. Install a tailwater depression system. Modify other Pit 7ancillary facilities.	Increase height of training walls on dam spillway. Install a tailwater depression system. Modify other Pit 7ancillary facilities.	Increase height of training walls on dam spillway. Install a tailwater depression system. Modify other Pit 7ancillary facilities.	Increase height of training walls on dam spillway. Install a tailwater depression system. Modify other Pit 7ancillary facilities.	Increase height of training walls on dam spillway. Install a tailwater depression system. Modify other Pit 7ancillary facilities.
Reservoir Area Clearing	Clear 150 acres completely and 220 acres with overstory removal.	Clear 240 acres completely and 350 acres with overstory removal.	Clear 340 acres completely and 500 acres with overstory removal.	Clear 340 acres completely and 500 acres with overstory removal.	Clear 340 acres completely and 500 acres with overstory removal.	Clear 340 acres completely and 500 acres with overstory removal.
Reservoir Area Dikes and Railroad Embankments	Construct 3 railroad embankments and 2 new dikes.	Construct 3 railroad embankments and 3 new dikes.	Construct 3 railroad embankments and 4 new dikes.	Construct 3 railroad embankments and 4 new dikes.	Construct 3 railroad embankments and 4 new dikes.	Construct 3 railroad embankments and 4 new dikes.
Relocations						
Roadways	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.	Match replacement widths to existing paved roads to be replaced.
Length of Relocated Roadway (linear feet)	16,700	28,400	33,100	33,100	33,100	33,100
Number of Road Segments Affected	10	21	30	30	30	30
Vehicle Bridges	Relocate 4 bridges, modify 1 bridge.	Relocate 4 bridges, modify 1 bridge.	Relocate 4 bridges, modify 1 bridge.	Relocate 4 bridges, modify 1 bridge.	Relocate 4 bridges, modify 1 bridge.	Relocate 4 bridges, modify 1 bridge.
Railroad	Relocate 2 bridges and realign track in-between, modify 1 bridge	Relocate 2 bridges and realign track in-between, modify 1 bridge	Relocate 2 bridges and realign track in-between, modify 1 bridge	Relocate 2 bridges and realign track in-between, modify 1 bridge	Relocate 2 bridges and realign track in-between, modify 1 bridge	Relocate 2 bridges and realign track in-between, modify 1 bridge
Recreation Facilities	Modify or replace 9 marinas, 6 public boat ramps, 6 resorts, 202 campsites/day-use sites/RV sites, 2 USFS facilities, 8.1 miles of trail, and 2 trailheads.	Modify or replace 9 marinas, 6 public boat ramps, 6 resorts, 261 campsites/ day-use sites/RV sites, 2 USFS facilities, 9.9 miles of trail, and 2 trailheads.	Modify or replace 9 marinas, 6 public boat ramps, 6 resorts, 328 campgrounds/day-use areas/RV sites, 2 USFS facilities, 11.6 miles of trail, and 2 trailheads.	Modify or replace 9 marinas, 6 public boat ramps, 6 resorts, 328 campgrounds/day-use areas/RV sites, 2 USFS facilities, 11.6 miles of trail, and 2 trailheads.	Modify or replace 9 marinas, 6 public boat ramps, 6 resorts, 328 campgrounds/day-use areas/RV sites, 2 USFS facilities, 11.6 miles of trail, and 2 trailheads.	Modify or replace 9 marinas, 6 public boat ramps, 6 resorts, 328 campgrounds/day-use areas/RV sites, 2 USFS facilities, 11.6 miles of trail, and 2 trailheads. Add 6 trailheads and18 miles of new hiking trails.

Table 5-6. Summary of Physical Features of Comprehensive Plans (contd.)

Main Features	Comprehensive plans					
	CP1	CP2	CP3	CP4	CP4A	CP5
Utilities	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.	Relocate inundated utilities. Construct wastewater treatment facilities.
Ecosystem Enhancements	None	None	None	Reserve 378 TAF of the additional storage for cold-water supply for anadromous fish. Implement adaptive management plan to benefit anadromous fish. Augment spawning gravel in the upper Sacramento River at the rate of up to 10,000 tons per year. Restore riparian, floodplain, and side channel habitat along the upper Sacramento River.	Reserve 191 TAF of the additional storage for cold-water supply for anadromous fish. Implement adaptive management plan to benefit anadromous fish. Augment spawning gravel in the upper Sacramento River at the rate of up to 10,000 tons per year. Restore riparian, floodplain, and side channel habitat along the upper Sacramento River.	Construct shoreline fish habitat around Shasta Lake. Enhance aquatic habitat in tributaries to Shasta Lake to improve fish passage. Augment spawning gravel in the upper Sacramento River at the rate of up to 10,000 tons per year. Restore riparian, floodplain, and side channel habitat along the upper Sacramento River.

Notes:
[1] Dam crest elevations are based on the National Geodetic Vertical Datum of 1929 (NGVD29). All current feasibility-level designs and figures for Shasta Dam and appurtenant structures are based on NGVD29.
[2] Full pool elevations are based on the North American Vertical Datum of 1988 (NAVD88), which is 2.66 feet higher than NGVD29. All current feasibility-level designs and figures for reservoir area infrastructure modifications and relocations to accommodate increased water levels are based on a 2001 aerial survey of the reservoir using NAVD88.

Key:
CP = comprehensive plan
RV = recreational vehicle
TAF = thousand acre-feet
USFS = U.S. Department of Agriculture, Forest Service

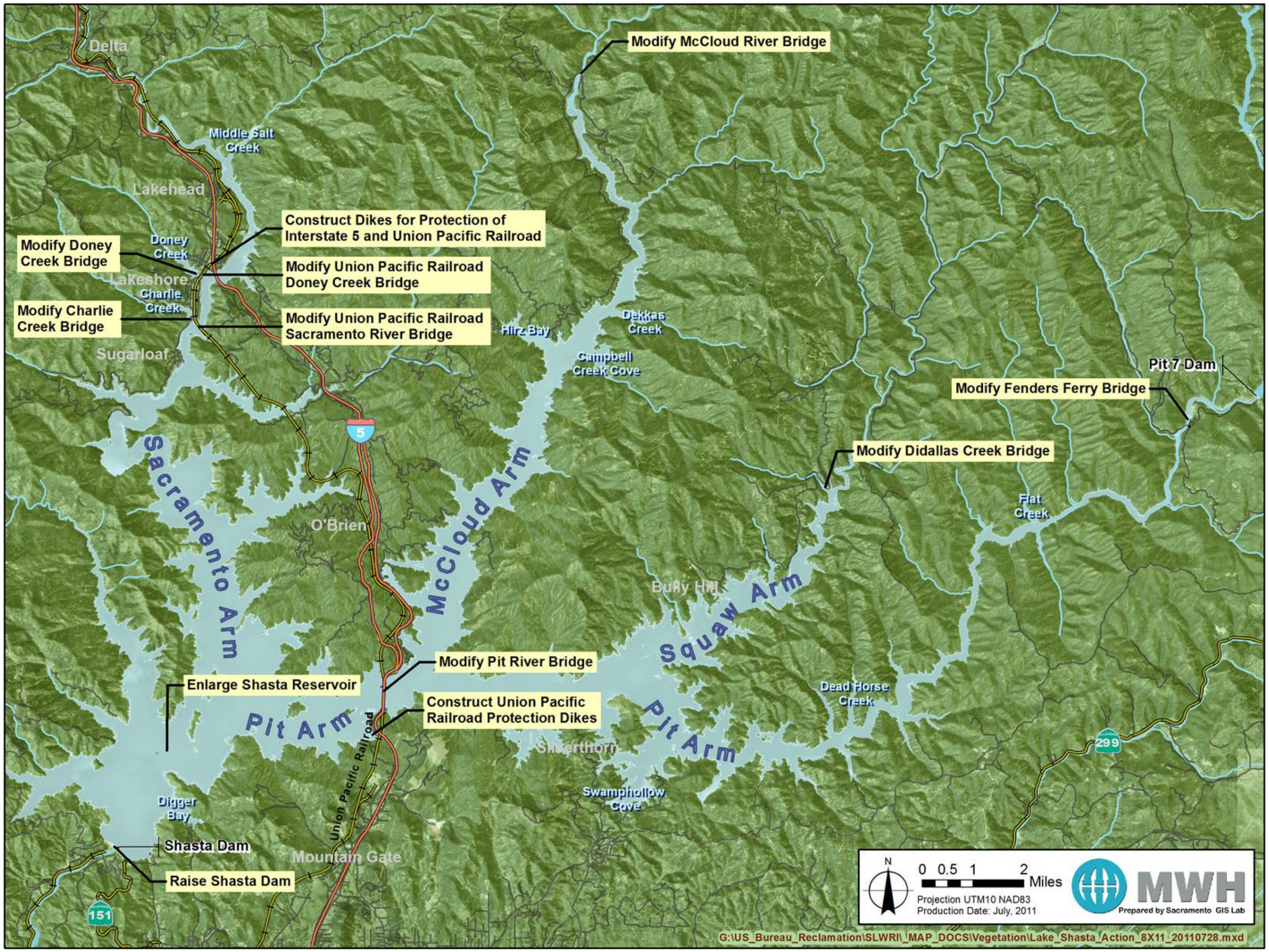


Figure 5-3. Major Features Common to All Comprehensive Plans

CP1 – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability

CP1 was formulated to represent a likely minimum raise of Shasta Dam, and consists primarily of enlarging Shasta Dam by raising the crest 6.5 feet and enlarging the reservoir by 256,000 acre-feet. Major features of CP1 are shown in Figure 5-3 and summarized in Table 5-6.

Major Components of CP1

CP1 includes the following major components:

- Raising Shasta Dam and appurtenant facilities by 6.5 feet
- Implementing the set of eight common management measures described above
- Implementing the common environmental commitments described above

As shown in Table 5-6, by raising Shasta Dam 6.5 feet, from crest elevation of 1,077.5 feet to 1,084.0 feet (based on the National Geodetic Vertical Datum 1929 (NGVD29)),[1] CP1 would increase the height of the reservoir full pool by 8.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications, including replacing the three drum gates with six sloping fixed-wheel gates. This increase in full pool height would add approximately 256,000 acre-feet of additional storage to the overall reservoir capacity. Accordingly, the overall full pool storage would increase from 4.55 MAF to 4.81 MAF. Figure 5-4 shows the increase in surface area and storage capacity for each dam raise.

Under CP1, the additional storage in Shasta Reservoir would be used to increase water supply reliability and to expand the cold-water pool for downstream anadromous fisheries. This alternative (and all comprehensive plans) involves extending the existing TCD for efficient use of the expanded cold-water pool. Operations for water supply, hydropower, and environmental and other regulatory requirements would be similar to existing operations, except during dry and critical years when a portion of the increased storage capacity in Shasta Reservoir would be reserved to specifically focus on increasing M&I deliveries. In dry years, 70,000 acre-feet of the 256,000 acre-feet increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. In critical years, 35,000 acre-feet of the increased storage capacity would be reserved for increasing M&I deliveries.

[1] Dam crest elevations are based on NGVD29. All current feasibility-level designs and figures for Shasta Dam and appurtenant structures are based on NGVD29.

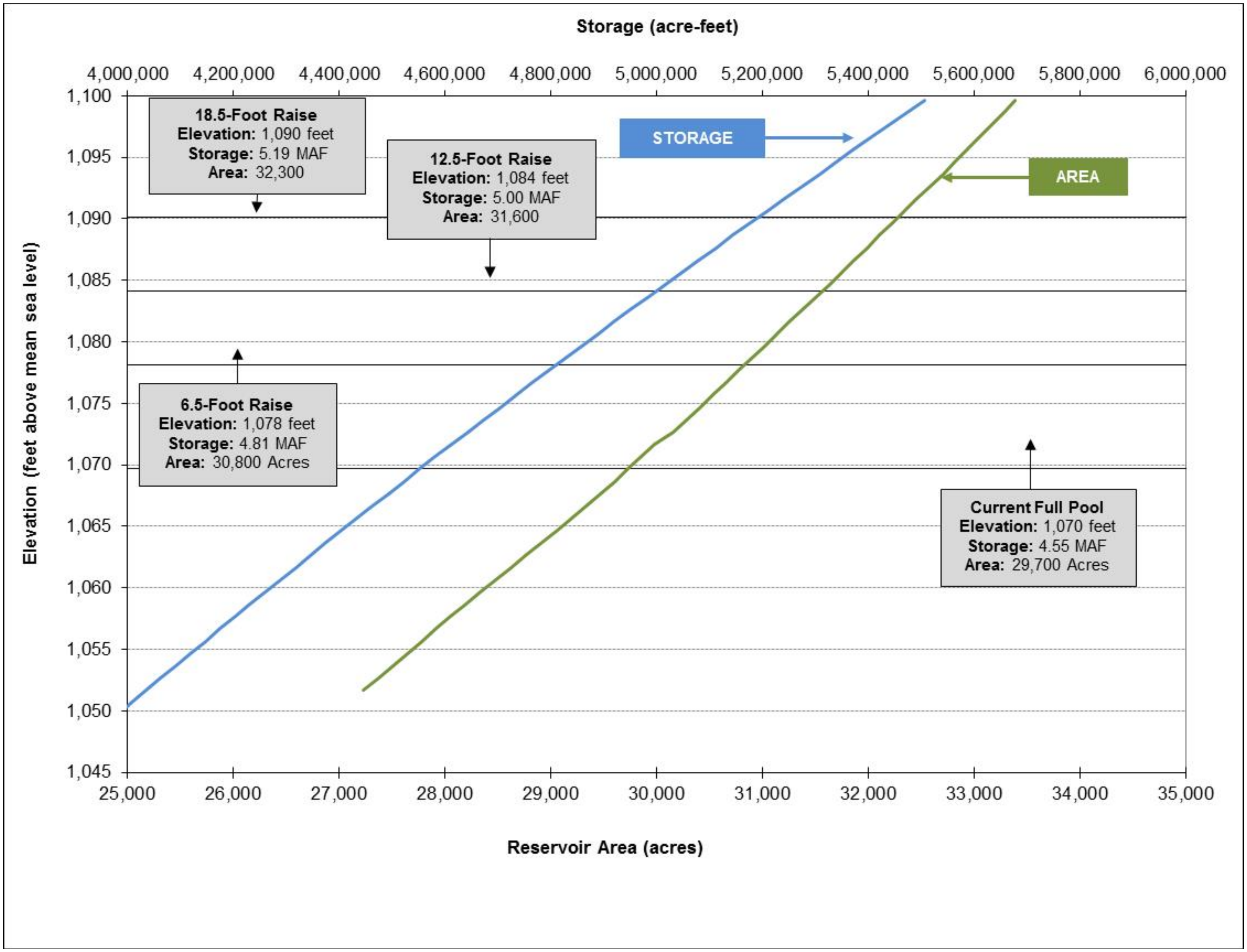


Figure 5-4. Enlarged Shasta Reservoir Area Capacity Relationships (elevations based on NAVD88)

CP1 would also include the potential to revise the operational rules for flood control at Shasta Dam and Reservoir, which could reduce the potential for flood damage, and benefit recreation. Although the volume of the flood control pool would remain the same as under existing operations (1.3 MAF), the bottom of the flood control pool elevation would likely be increased based on increased dam height and reservoir capacity. Because of reservoir geometry, this would decrease the depth of the flood control pool, allowing higher winter and spring water levels. Increased reservoir capacity could have further flood damage reduction benefits in years when water levels are below the new flood control pool elevation.

A limited potential also exists for changes in flood control rules to allow more operational flexibility in reservoir drawdown requirements in response to storms, resulting in a net increase in the rate of spring reservoir filling during some years. The ability to revise the operational rules might result from using advanced weather forecasting tools and enhanced basin monitoring, which may be included during refinement of operational parameters after authorization. Higher spring water levels and associated increases in reservoir surface area would benefit recreation.

Construction for CP1

Construction activities associated with physical features under CP1 would include land-based construction activities associated with the following:

- Clearing vegetation from portions of the inundated reservoir area
- Constructing the dam raise, appurtenant structures, reservoir area dikes, and railroad embankments
- Relocating roadways, bridges, recreation facilities, utilities, and miscellaneous minor infrastructure

Construction activities for CP1 are described in detail in the Engineering Summary Appendix.

Operations and Maintenance for CP1

Shasta Dam is operated in conjunction with other CVP facilities and SWP facilities to manage floodwater, storage of surplus winter runoff for irrigation in the Sacramento and San Joaquin valleys, M&I use, maintenance of navigation flows, protection and conservation of fish in the Sacramento River and Delta, and generation of hydroelectric energy. Storage in Shasta Reservoir fluctuates greatly throughout the year; storage is typically highest at the end of winter, in April and May, as the need for flood control reservation space in the reservoir decreases. Storage is typically at its lowest in September and October, after the irrigation season and before winter refill begins. Shasta Reservoir capacity is currently 4.552 MAF, with a maximum objective release capacity of 79,000 cfs. Storage levels are lowest by October to provide sufficient flood risk reduction and capture capacity during the following wet months. The storage target gradually increases beginning in October to full pool in May; storage is then withdrawn for high water demand (e.g., agricultural, M&I, fishery, and water quality uses) during summer.

A series of rules and regulations in the form of flood control requirements, flow requirements, water quality requirements, and water supply commitments governs operations at Shasta Dam. Federal and State laws, regulations, standards, and plans regulating Shasta Dam operations are described in detail in Chapter 6 of the EIS, "Hydrology, Hydraulics, and Water Management," and include the following:

- 2009 NMFS BO (NMFS 2009)
- 2008 USFWS BO (USFWS 2008)
- CVPIA Programmatic EIS (Reclamation 1999)
- CVP long-term water service contracts (see *Hydrology, Hydraulics, and Water Management Technical Report*, Table 1-25)
- Trinity River ROD (Reclamation 2000)
- 2008 Long-Term Operation BA (Reclamation 2008)
- Flood management requirements in accordance with the Water Control Manual (USACE 1977)
- State Water Board Orders 90-05 and 91-01
- California Department of Fish and Game and Reclamation Memorandum of Agreement (CDFG and Reclamation 1960)
- Water Quality Control Plan for the San Francisco Bay/San Joaquin Delta Estuary (State Water Board 1995)
- State Water Board Water Right Revised Decision 1641 (State Water Board 2000)
- CVP and SWP Coordinated Operations Agreement (Reclamation and DWR 1986)

In addition, Shasta Dam and Reservoir are operated according to the *Standing Operating Procedures for Shasta Dam and Reservoir*. However, due to sensitivity regarding this information, including security and public health and safety concerns, this document is not available to the general public.

Under CP1, the additional storage would be retained to increase water supply reliability and to expand the cold-water pool in Shasta Reservoir for fisheries benefits. Shasta Dam operational guidelines would continue unchanged, except during dry years and critical years, when 70,000 acre-feet and 35,000 acre-feet, respectively, of the 256,000 acre-feet increased storage capacity in Shasta Reservoir would be operated primarily to increase M&I deliveries. Operations targeting increased M&I deliveries were based on existing and anticipated future demands, operational priorities, and facilities of the SWP, which provides M&I water to a majority of the State's population. For this EIS, these operations were simulated in CalSim-II by using the reserved storage capacity to provide deliveries for previously unmet SWP demands during dry and critical years. For CP1, existing water quality and temperature requirements would typically be met in most years; therefore, additional water in storage would be released primarily for water supply purposes. Accordingly, minimal increases in flow would be expected in months when Delta exports were constrained, or when flow was not required for water supply purposes.

In comparison to current operations, CP1 would store some additional flows behind Shasta Dam during periods when downstream needs would have already been met, but flows would have been released because of storage limitations. The resulting increase in storage would be released downstream when there were opportunities for beneficial use of the water, either to meet water supply reliability demands or to improve Reclamation's abilities to meet its environmental objectives. The additional water in storage would also expand the cold-water pool and increase end-of-September carryover storage in Shasta Reservoir, increasing the ability of Shasta Dam to improve water temperatures for anadromous fish in the upper Sacramento River.

Conversely, if water in storage were insufficient to meet all of the project purposes, the first increment to be reduced would be deliveries to water service contractors. Releases from Shasta Dam under CP1 would typically increase in the summer months, corresponding with the periods of greatest agricultural demands. Similarly, releases would be reduced in the winter months, when the increased storage space could be used to capture additional runoff rather than releasing water to the downstream river, as would occur under Shasta Reservoir's current operations.

Maintenance of facilities related to the proposed dam and reservoir enlargement would be similar to maintenance activities currently conducted at Shasta Dam and Reservoir.

Operation of pumping facilities downstream from Shasta Dam would vary slightly from current operations and would result in higher costs. In addition, Reclamation would provide in-kind power to offset reduced generation at Pit 7 Dam and related facilities.

Potential Benefits of CP1

Major potential benefits of CP1 related to contributions to the planning objectives and broad public services, are described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors affecting anadromous fish survival in the Sacramento River. CP1 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critical water years. This would be accomplished by raising Shasta Dam 6.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBPP. Hence, the most significant benefits to anadromous fish would occur upstream from the RBPP. It is estimated that under CP1, improved water temperature and flow conditions could result in an average annual increase in the salmon population of about 61,300 out-migrating juvenile Chinook salmon per year.[2]

Figure 5-5 shows an exceedence probability relationship of maximum annual storage in Shasta Lake for CP1 and other comprehensive plans compared to the No-Action Alternative, illustrating expected increases in storage volumes under each comprehensive plan. Storage volumes for Figure 5-5 were simulated with the CalSim-II model as discussed in detail in the Modeling Appendix. Figure 5-6 shows simulated reservoir storage fluctuations for the No-Action Alternative and CP1 for a representative period of 1972 through 2003.

[2] Estimates of increased anadromous fish survival were based on simulations using the SALMOD model. These estimates represent an index of production increase, based on the simulated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the RBPP.

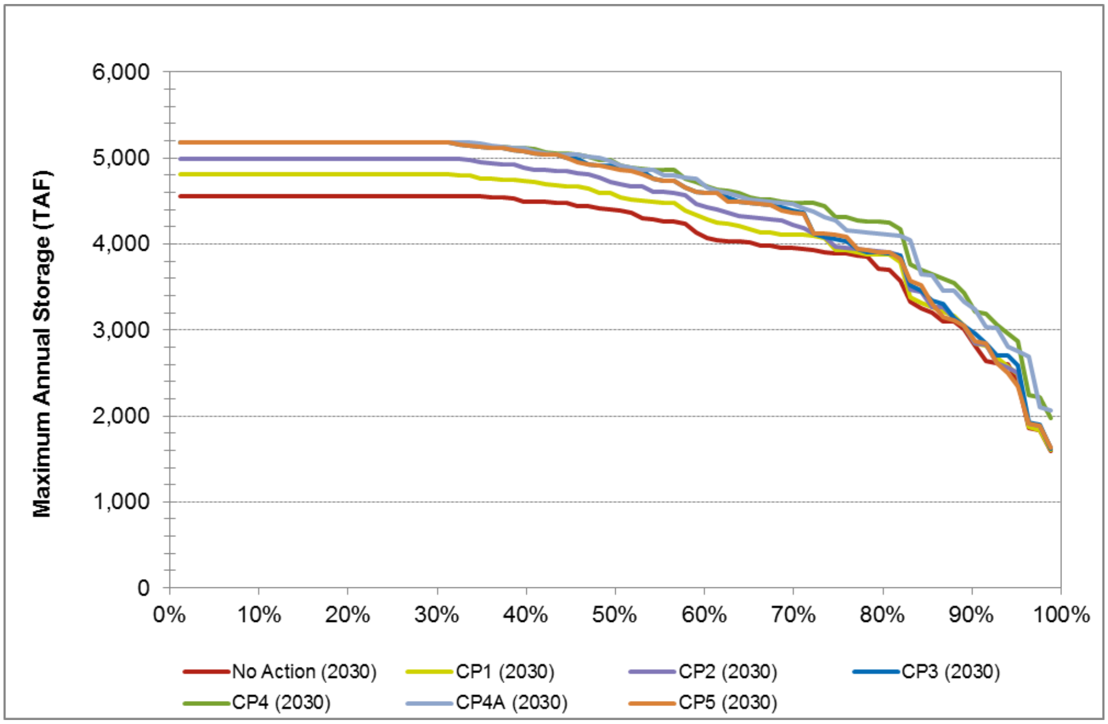


Figure 5-5. Simulated Exceedence Probability Relationship of Maximum Annual Storage in Shasta Lake for a Future Level of Development (2030)

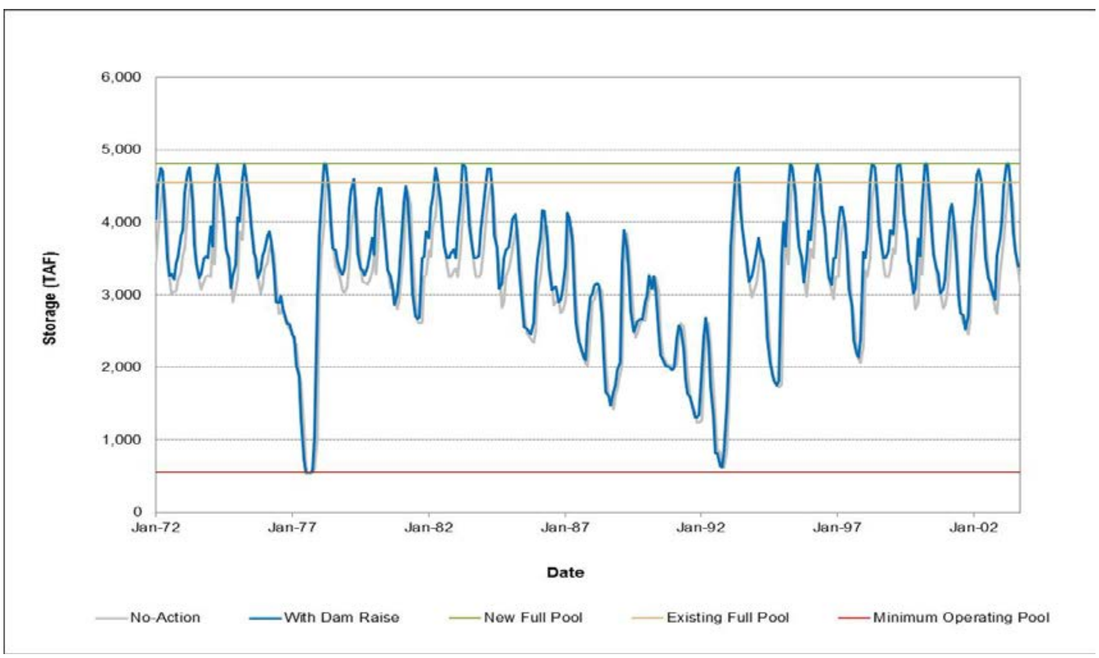
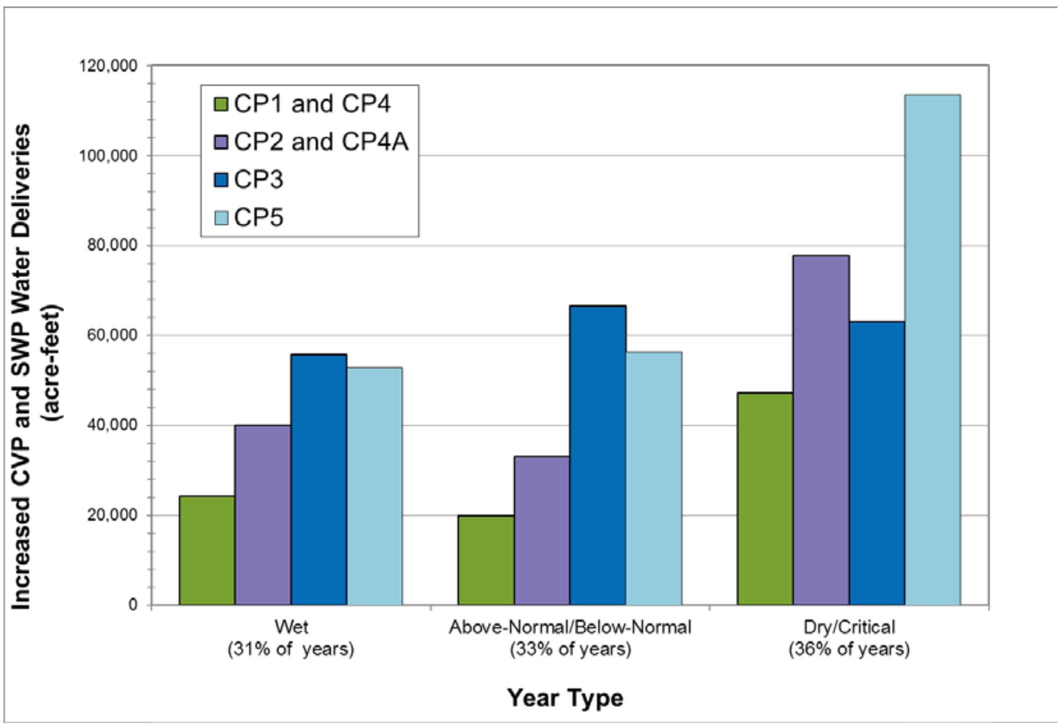


Figure 5-6. Simulated Shasta Reservoir Storage from 1972 to 2003 for the No-Action Alternative and CP1

Increase Water Supply Reliability CP1 would increase water supply reliability by increasing water supplies for CVP and SWP irrigation and M&I deliveries. Resulting increases in deliveries, based on CalSim-II modeling results, are shown in Figure 5-7 and Table 5-7. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. CP1would help reduce estimated future water shortages by increasing dry and critical year water supplies for agricultural and M&I deliveries by at least 47,300 acre-feet per year and average annual deliveries by about 31,000 acre-feet per year. As shown in Table 5-7, the majority of increased dry and critical year water supplies, 42,700 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP1, about $1.6 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.



Note: Deliveries were simulated using CalSim-II and water year types were based on the Sacramento Valley Water Year Hydrologic Classification.

Figure 5-7. Comparison of Increased CVP and SWP Water Deliveries by Year Type for Comprehensive Plans

Table 5-7. Increases in CVP and SWP Water Deliveries for Comprehensive Plans

Total CVP/SWP Deliveries	Average All Years				Dry and Critical Years[2]			
	CP1/CP4 (acre-feet)	CP2/CP4A (acre-feet)	CP3 (acre-feet)	CP5 (acre-feet)	CP1/CP4 (acre-feet)	CP2/CP4A (acre-feet)	CP3 (acre-feet)	CP5 (acre-feet)
North of Delta								
Agriculture	5,900	10,900	25,900	19,600	4,200	9,500	29,400	21,100
M&I	100	1,400	4,400	3,300	300	1,200	5,800	4,100
Total	6,000	12,300	30,300	22,900	4,500	10,700	35,200	25,200
South of Delta								
Agriculture	14,400	20,500	36,400	31,300	18,300	28,100	41,300	45,000
M&I	10,600	18,500	(4,900)	21,700	24,400	39,000	(13,300)	43,300
Total	25,000	39,000	31,500	53,000	42,700	67,100	28,000	88,300
Combined North and South of Delta								
Agriculture[1]	20,300	31,400	62,200	50,900	22,500	37,600	70,600	66,100
M&I[1]	10,700	19,900	(500)	25,000	24,700	40,200	(7,500)	47,400
Total[1]	***31,000***	***51,300***	***61,700***	***75,900***	***47,300***	***77,800***	***63,100***	***113,500***

Notes:
[1] Totals may not sum due to rounding.
[2] Based on the Sacramento Valley Water Year Hydrologic Classification

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
M&I = Municipal and Industrial
SWP = State Water Project

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 52 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities. Other power benefits include additional capacity (i.e., the rate at which power can be generated) and ancillary services, which provide the ability to manage the electric grid in a reliable manner.

Maintain and Increase Recreation Opportunities CP1 includes features to at least maintain the existing recreation capacity at Shasta Lake. Although CP1 does not include specific features to further increase recreation capacity, benefits to the water-oriented recreation experience at Shasta Lake would likely occur because of the increase in average lake surface area, reduced drawdown during the recreation season, and modernization of recreation facilities. The maximum surface area of the lake would increase by about 1,110 acres (4 percent), from 29,700 to about 30,800 acres. The average surface area of the lake during the recreation season from May through September would increase by about 800 acres (3 percent), from 23,900 acres to 24,700 acres. There is also limited potential to provide additional benefits to recreation by allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other Planning Objectives CP1 could also provide benefits related to flood damage reduction, ecosystem restoration, and water quality. Enlarging Shasta Dam would provide for incidental increased reservoir capacity to capture flood flows, which could reduce flood damage along the upper Sacramento River. Improved fisheries conditions as a result of CP1, as described above, and increased flexibility to meet flow and temperature requirements, could also enhance overall ecosystem resources in the Sacramento River. For example, increasing anadromous fish survival could inherently benefit other species that prey on adult and juvenile anadromous fish, and increased storage could provide water that would have otherwise been unavailable to improve flow and temperature conditions during a multiple year drought. Furthermore, CP1 could potentially benefit ecosystem restoration through improved Delta water quality conditions by increasing Delta outflow during drought years and reducing salinity during critical periods. CP1 may also contribute to improving Delta water quality through increased Delta emergency response capabilities. When Delta emergencies occur, additional water in Shasta Reservoir could improve operation flexibility for increasing releases to supplement existing water sources to reestablish Delta water quality. In addition to Delta emergency response, increased storage in Shasta Reservoir could increase emergency response capability for CVP/SWP water supply deliveries.

Additional Broad Public Benefits Additional broad public benefits of CP1 (and all comprehensive plans) obtained through pursuing project objectives are summarized in Table 5-8. These include benefits to reservoir water quality, traffic and transportation, and public services from modernization and upgrades of relocated facilities. Long-term benefits to air quality, groundwater, Shasta Lake fisheries, and system-wide operations are due to increased overall system capacity, allowing for increases in clean energy production, surface water deliveries, and storage capacity in Shasta Reservoir.

Table 5-8. Summary of Additional Broad Public Benefits for SLWRI Comprehensive Plans

Category	Benefit Description
System-Wide Water Management Flexibility	All CPs improve system-wide water management flexibility for storage and operations to meet multiple competing public objectives
Air Quality	All CPs would provide for increased clean energy generation potentially reducing GHG emissions
Groundwater	All CPs allow for decreased groundwater pumping and related groundwater overdraft conditions in CVP/SWP water service areas
Reservoir Water Quality	All CPs replace reservoir area septic systems with centralized wastewater treatment plants
Shasta Lake Cold-Water Fisheries	All CPs improve Shasta Lake cold-water fisheries conditions through increasing the cold-water pool
Traffic and Transportation	All CPs modernize relocated roadways and bridges with facilities designed to meet current public safety standards
Public Services	All CPs relocate USFS emergency response facilities to a more centralized location adjacent to interstate transportation corridors

Notes:
[1] Broad public benefits listed above are additional to benefits associated with project objectives.

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
GHG = greenhouse gas
SWP = State Water Project
USFS = U.S. Forest Service

Potential Primary Effects from CP1

Several potential environmental consequences of CP1 are included in this section. A detailed discussion of potential effects and proposed mitigation measures for CP1 are included in Chapters 4 through 25 of the EIS and summarized in Table 5-9 below.

Shasta Lake Area Within the reservoir area, the primary long-term impacts of this and other comprehensive plans would be due to the increased water surface elevations and inundation area and/or indirect effects related to facility modifications and relocations. Raising the full pool of the lake would cause direct impacts due to higher water surface elevations and inundation area. General types of impacts would include potential inundation of terrestrial and aquatic habitat, and inundation and resulting relocation of buildings, sections of paved and nonpaved roads, campground facilities (such as parking areas and restrooms), and low-lying bridges. Use of, and access to, recreation facilities also would be impacted, including trails, day-use picnic areas, boat ramps, marinas, campgrounds, resorts, and beaches. Several of the main buildings associated with Bridge Bay Resort and Marina, the largest resort and marina complex on Shasta Lake, are located within a few feet of the existing full pool elevation. Any potential real estate acquisition, or necessary relocations of displaced parties, would be accomplished under Public Law 91-646.

The without-project and with-project relationship of water stored in Shasta Reservoir is shown in Figure 5-4. Figure 5-5 shows the exceedence probability of maximum annual storages in Shasta Reservoir. From these graphics, it can be seen that Shasta Reservoir fills to (or near) full pool levels in the without-project condition about once every 3 years (about 35 percent of the years). In addition, on the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent capacity in about 81 percent of the years over the 82-year period of analysis of the CalSim-II model. With this plan, Shasta would fill to the new full pool storage of 4.81 MAF at about the same frequency as under without-project conditions – about once every 3 years. Further, Shasta Lake would also fill to 80 percent of the new capacity in about 81 percent of the years. Accordingly, annual operations in the reservoir generally would mirror existing operations except the water surface in the lake would be about 8.5 feet higher. The primary difference in additional reservoir area exposed under without-project versus with-project conditions would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans

Resource Topic/Impact	Alternative	Mitigation Measure
Geology, Geomorphology, Minerals, and Soils		
Impact Geo-2: Alteration of Fluvial Geomorphology and Hydrology of Aquatic Habitats	CP1 – CP5	Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.
Impact Geo-9: Substantial Increase in Channel Erosion and Meander Migration	CP1 – CP5	Mitigation Measure Geo-9: Modification of Flow Releases in Response to River Management and Habitat Restoration Efforts between Keswick Dam and Red Bluff.
Air Quality and Climate		
Impact AQ-1: Short-Term Emissions of Criteria Air Pollutants and Precursors at Shasta Lake and Vicinity During Project Construction	CP1 – CP5	Mitigation Measure AQ-1: Implement Standard Measures and Best Available Mitigation Measures to Reduce Emissions Levels.
Hydrology, Hydraulics, and Water Management		
No mitigation measures proposed.		
Water Quality		
Impact WQ-1: Temporary Construction-Related Sediment Effects on Shasta Lake and Its Tributaries that Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses	CP1 – CP5	Mitigation Measure WQ-1: Develop and Implement a Comprehensive Multi-scale Sediment Reduction and Water Quality Improvement Program Within Watersheds Tributary to the Primary Study Area.
Impact WQ-4: Long-Term Sediment Effects that Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in Shasta Lake or Its Tributaries	CP1 – CP5	Mitigation Measure WQ-4: Implement Mitigation Measure WQ-1 (CP1): Develop and Implement a Comprehensive Multi-scale Sediment Reduction and Water Quality Improvement Program Within Watersheds Tributary to the Primary Study Area.
WQ-6: Long-Term Metals Effects that Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in Shasta Lake or Its Tributaries	CP1 – CP5	Mitigation Measure WQ-6: Prepare and Implement a Site-Specific Remediation Plan for Historic Mine Features Subject to Inundation in the Vicinity of the Bully Hill and Rising Star Mines.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact WQ-7: Temporary Construction-Related Sediment Effects on the Upper Sacramento River that Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses	CP1 – CP5	Mitigation Measure WQ-7: Implement Mitigation Measure WQ-1 (CP1): Develop and Implement a Comprehensive Multi-scale Sediment Reduction and Water Quality Improvement Program Within Watersheds Tributary to the Primary Study Area.
Impact WQ-12: Long-Term Metals Effects that Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in the Upper Sacramento River	CP1 – CP5	Mitigation Measure WQ-12: Implement Mitigation Measure WQ-6 (CP1): Prepare and Implement a Site-Specific Remediation Plan for Historic Mine Features Subject to Inundation in the Vicinity of the Bully Hill and Rising Star Mines
Impact WQ-18: Long-Term Metals Effects that Would Cause Violations of Water Quality Standards or Adversely Affect Beneficial Uses in the Extended Study Area	CP1 – CP5	Mitigation Measure WQ-18: Implement Mitigation Measure WQ-6 (CP1): Prepare and Implement a Site-Specific Remediation Plan for Historic Mine Features Subject to Inundation in the Vicinity of the Bully Hill and Rising Star Mines
Noise and Vibration		
Impact Noise-1: Exposure of Sensitive Receptors in the Primary Study Area to Project-Generated Construction Noise	CP1 – CP5	Mitigation Measure Noise-1: Implement Measures to Prevent Exposure of Sensitive Receptors to Temporary Construction Noise at Project Construction Sites.
Hazards and Hazardous Materials and Waste		
Impact Haz-1: Wildland Fire Risk (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Haz-1: Coordinate and Assist Public Services Agencies to Reduce Fire Hazards.
Impact Haz-2: Release of Potentially Hazardous Materials or Hazardous Waste (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Haz-2: Reduce Potential for Release of Hazardous Materials and Waste.
Impact Haz-4: Exposure of Sensitive Receptors to Hazardous Materials (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Haz-4: Reduce Potential for Exposure of Sensitive Receptors to Hazardous Materials or Waste.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Agriculture and Important Farmlands		
No mitigation measures proposed.		
Fisheries and Aquatic Ecosystems		
Impact Aqua-4: Effects on Special-Status Aquatic Mollusks	CP1 – CP5	Mitigation Measure Aqua-4: Implement Mitigation Measure Geo-2: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.
Impact Aqua-7: Effects on Spawning and Rearing Habitat of Adfluvial Salmonids in Low-Gradient Tributaries to Shasta Lake	CP1 – CP5	Mitigation Measure Aqua-7: Implement Mitigation Measure Aqua-4: Replace Lost Ecological Functions of Aquatic Habitats by Restoring Existing Degraded Aquatic Habitats in the Vicinity of the Impact.
Impact Aqua-14: Reduction in Ecologically Important Geomorphic Processes in the Upper Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	CP1 – CP5	Mitigation Measure Aqua-14: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Aqua-15: Changes in Flow and Water Temperatures in the Lower Sacramento River and Tributaries and Trinity River Resulting from Project Operation – Fish Species of Primary Management Concern	CP1 – CP5	Mitigation Measure Aqua-15: Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements.
Impact Aqua-16: Reduction in Ecologically Important Geomorphic Processes in the Lower Sacramento River Resulting from Reduced Frequency and Magnitude of Intermediate to High Flows	CP1 – CP5	Mitigation Measure Aqua-16: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Botanical Resources and Wetlands		
Impact Bot-2: Loss of MSCS Covered Species	CP1 – CP5	Mitigation Measure Bot-2: Acquire and Preserve Mitigation Lands; Avoid Populations; Relocate MSCS Plants; and Revegetate Affected Areas.
Impact Bot-3: Loss of USFS Sensitive, BLM Sensitive, or CRPR Species	CP1 – CP5	Mitigation Measure Bot-3: Acquire and Preserve Mitigation Lands; Avoid Populations; Relocate USFS Sensitive, BLM Sensitive, and CRPR Plants and Revegetate Affected Areas.
Impact Bot-4: Loss of Jurisdictional Waters	CP1 – CP5	Mitigation Measure Bot-4: Mitigate Loss of Jurisdictional Waters.
Impact Bot-5: Loss of General Vegetation Habitats	CP1 – CP5	Mitigation Measure Bot-5: Acquire and Preserve Mitigation Lands for Loss of General Vegetation Habitats.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact Bot-6: Spread of Noxious and Invasive Weeds	CP1 – CP5	Mitigation Measure Bot-6: Develop and Implement a Weed Management Plan In Conjunction with Stakeholders.
Impact Bot-7: Altered Structure and Species Composition and Loss of Sensitive Plant Communities and Special-Status Plant Species Resulting from Altered Flow Regimes	CP1 – CP5	Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Bot-8: Conflict with Approved Local or Regional Plans with Objectives of Riparian Habitat Protection or Watershed Management	CP1 – CP5	Mitigation Measure Bot-8: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Bot-11: Loss of Sensitive Natural Communities or Habitats Resulting from Implementing the Gravel Augmentation Program or Restoring Riparian, Floodplain, and Side Channel Habitats	CP4 – CP5	Mitigation Measure Bot-11: Revegetate Disturbed Areas, Consult with CDFW, and Mitigate Loss of Jurisdictional Waters.
Impact Bot-12: Loss of Special-Status Plants Resulting from Implementing the Gravel Augmentation Program, or Restoring Riparian, Floodplain, and Side Channel Habitats	CP4 – CP5	Mitigation Measure Bot-12: Conduct Preconstruction Surveys for Special-Status Plants and Avoid Special-Status Plant Populations During Construction.
Impact Bot-13: Spread of Noxious and Invasive Weeds Resulting from Implementing the Gravel Augmentation Program, Restoring Riparian, Floodplain, and Side Channel Habitats	CP4 – CP5	Mitigation Measure Bot-13: Implement Weed Management Measures and Revegetation.
Impact Bot-14: Altered Structure and Species Composition and Loss of Sensitive Plant Communities and Special-Status Plant Species Resulting from Altered Flow Regimes on the Lower Sacramento River	CP1 – CP5	Mitigation Measure Bot-14: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Bot-15: Conflict with Approved Local or Regional Plans with Objectives of Riparian Habitat Protection or Watershed Management Along the Lower Sacramento River	CP1 – CP5	Mitigation Measure Bot-15: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Wildlife Resources		
Impact Wild-1: Take and Loss of Habitat for the Shasta Salamander	CP1 – CP5	Mitigation Measure Wild-1: Avoid, Relocate, and Acquire Mitigation Lands for Shasta Salamander.
Impact Wild-2: Impact on the Foothill Yellow-Legged Frog and Tailed Frog and Their Habitat	CP1 – CP5	Mitigation Measure Wild-2: Avoid, Relocate, and Acquire Mitigation Lands for Foothill Yellow-Legged Frog and Tailed Frog.
Impact Wild-3: Impact on the Northwestern Pond Turtle and Its Habitat	CP1 – CP5	Mitigation Measure Wild-3: Avoid, Relocate, and Acquire Mitigation Lands for Northwestern Pond Turtle.
Impact Wild-4: Impact on the American Peregrine Falcon	CP1 – CP5	Mitigation Measure Wild-4: Conduct Preconstruction Surveys for the American Peregrine Falcon and Establish Buffers.
Impact Wild-5: Take and Loss of Habitat for the Bald Eagle	CP1 – CP5	Mitigation Measure Wild-5: Acquire and Preserve Mitigation Lands; Conduct Protocol-Level Surveys for the Bald Eagle and Establish Buffers.
Impact Wild-6: Loss of Dispersal Habitat for the Northern Spotted Owl	CP1 – CP5	Mitigation Measure Wild-6: Acquire and Preserve Mitigation Lands, Habitat Enhancement.
Impact Wild-7: Impact on the Purple Martin and Its Habitat	CP1 – CP5	Mitigation Measure Wild-7: Conduct a Preconstruction Survey for Purple Martin and Establish Buffers.
Impact Wild-8: Impacts on the Willow Flycatcher, Vaux's Swift, Yellow Warbler, and Yellow-Breasted Chat and Their Foraging and Nesting Habitat	CP1 – CP5	Mitigation Measure Wild-8: Acquire and Preserve Mitigation Lands; Conduct a Preconstruction Survey for the Willow Flycatcher, Vaux's Swift, Yellow Warbler, and Yellow-Breasted Chat and Establish Buffers.
Impact Wild-9: Impacts on the Long-Eared Owl, Northern Goshawk, Cooper's Hawk, Great Blue Heron, and Osprey and Their Foraging and Nesting Habitat	CP1 – CP5	Mitigation Measure Wild-9: Acquire and Preserve Mitigation Lands; Conduct a Preconstruction Survey for the Long-Eared Owl, Northern Goshawk, Cooper's Hawk, Great Blue Heron, and Osprey and Establish Buffers.
Impact Wild-10: Take and Loss of Habitat for the Pacific Fisher	CP1 – CP5	Mitigation Measure Wild-10: Acquire and Preserve Mitigation Lands; Conduct Preconstruction Surveys for the Pacific Fisher and Establish Buffers.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact Wild-11: Impacts on Special-Status Bats (Pallid Bat, Spotted Bat, Western Red Bat, Western Mastiff Bat, Townsend's Big-Eared Bat, Long-Eared Myotis, and Yuma Myotis), the American Marten, and Ringtails and Their Habitat	CP1 – CP5	Mitigation Measure Wild-11: Acquire and Preserve Mitigation Lands; Conduct a Preconstruction Survey for Special-Status Bats, American Marten, and Ringtails and Establish Buffers.
Impact Wild-12: Impacts on Special-Status Terrestrial Mollusks (Shasta Sideband, Wintu Sideband, Shasta Chaparral, and Shasta Hesperian) and Their Habitat	CP1 – CP5	Mitigation Measure Wild-12: Avoid Suitable Habitat; Acquire and Preserve Mitigation Lands for Special-Status Terrestrial Mollusks.
Impact Wild-13: Permanent Loss of General Wildlife Habitat	CP1 – CP5	Mitigation Measure Wild-13: Acquire and Preserve Mitigation Lands for Permanent Loss of General Wildlife Habitat.
Impact Wild-14: Impacts on Other Birds of Prey (Red-Tailed Hawk and Red-Shouldered Hawk) and Migratory Bird Species (American Robin, Anna's Hummingbird) and Their Foraging and Nesting Habitat	CP1 – CP5	Mitigation Measure Wild-14: Acquire and Preserve Mitigation Lands and Conduct Preconstruction Surveys for Other Nesting Raptors and Migratory Birds and Establish Buffers.
Impact Wild-15: Loss of Critical Deer Winter and Fawning Range	CP1 – CP5	Mitigation Measure Wild-15: Acquire and Preserve Mitigation Lands for Permanent Loss of Critical Deer Wintering and Fawning Range.
Impact Wild-16: Take and Loss of California Red-Legged Frog	CP1 – CP5	TBD
Impact Wild-17: Impacts on Riparian-Associated Special-Status Wildlife Resulting from Modifications to the Existing Flow Regime in the Primary Study Area	CP1 – CP5	Mitigation Measure Wild-17: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Wild-20: Consistency with Local and Regional Plans with Goals of Promoting Riparian Habitat in the Primary Study Area	CP1 – CP5	Mitigation Measure Wild-20: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Wild-21: Impacts on Riparian-Associated Special-Status Wildlife Resulting from the Gravel Augmentation Program	CP4 – CP5	Mitigation Measure Wild-21: Conduct Preconstruction Surveys for Elderberry Shrubs, Northwestern Pond Turtle, and Nesting Riparian Raptors and Other Nesting Birds. Avoid Removal or Degradation of Elderberry Shrubs and Avoid Vegetation Removal near Active Nest Sites.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Impact Wild-22: Impacts on Riparian-Associated Special-Status Wildlife Species Resulting from Restoration Projects	CP4 – CP5	Mitigation Measure Wild-22: Implement Mitigation Measure Wild-21: Conduct Preconstruction Surveys for Elderberry Shrubs, Northwestern Pond Turtle, and Nesting Riparian Raptors and Other Nesting Birds. Avoid Removal or Degradation of Elderberry Shrubs and Avoid Vegetation Removal near Active Nest Sites.
Impact Wild-23: Impacts on Riparian-Associated and Aquatic Special-Status Wildlife Resulting from Modifications to Existing Flow Regimes in the Lower Sacramento River and Delta	CP1 – CP5	Mitigation Measure Wild-23: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Impact Wild-26: Consistency with Local and Regional Plans with Goals of Promoting Riparian Habitat along the Lower Sacramento River and in the Delta	CP1 – CP5	Mitigation Measure Wild-26: Implement Mitigation Measure Bot-7: Implement a Riverine Ecosystem Mitigation and Adaptive Management Plan to Avoid and Compensate for the Impact of Altered Flow Regimes on Riparian and Wetland Communities.
Cultural Resources		
Impact Culture-1: Disturbance or Destruction of Archaeological and Historical Resources Due to Construction or Inundation	CP1 – CP5	Mitigation Measure Culture-1: Develop and Implement measures identified in an NHPA Section 106 MOA or PA.
Impact Culture-2: Inundation of Traditional Cultural Properties	CP4 – CP5	Mitigation Measure Culture-2: Adverse effects will be avoided, minimized, or mitigated through project redesign, when warranted, or through the development and implementation of an MOA or PA.
Impact Culture-3: Disturbance or Destruction of Archaeological and Historical Resources near the Upper Sacramento River Due to Construction	CP4 – CP5	Mitigation Measure Culture-3: Implement Mitigation Measure Culture-1: Develop and Implement measures identified in an NHPA Section 106 MOA or PA.
Indian Trust Assets		
No mitigation measures proposed.		
Socioeconomics, Population, and Housing		
Impact Socio-14: Potential Temporary Reduction in Shasta Project Water or Hydropower Supplied to the CVP and SWP Service Areas During Construction	CP1 – CP5	Mitigation Measure Socio-14: Secure Replacement Water or Hydropower During Project Construction.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Land Use Planning		
Impact LU-1: Disruption of Existing Land Uses (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure LU-1: Minimize and/or Avoid Temporary Disruptions to Local Communities.
Impact LU-2: Conflict with Existing Land Use Goals and Policies of Affected Jurisdictions (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure LU-2: Minimize and/or Avoid Conflicts with Land Use Goals and Policies.
Recreation and Public Access		
Impact Rec-2: Temporary Construction-Related Disruption of Recreation Access and Activities at and near Shasta Dam	CP1 – CP5	Mitigation Measure Rec-2: Provide Information About and Improve Alternate Recreation Access and Opportunities to Mitigate the Temporary Loss of Recreation Access and Opportunities During Construction at Shasta Dam.
Impact Rec-4: Increased Hazards to Boaters and Other Recreationists at Shasta Lake from Standing Timber and Stumps Remaining in Untreated Areas of the Inundation Zone	CP1 – CP5	Mitigation Measure Rec-4: Provide Information to Shasta Lake Visitors About Potential Safety Hazards in Newly Inundated Areas from Standing Timber and Stumps.
Impact Rec-15: Increased Difficulty for Boaters and Anglers in Using the Sacramento River and Rivers Below CVP and SWP Reservoirs as a Result of Decreased River Flows	CP1 – CP5	Mitigation Measure Rec-15: Implement Mitigation Measure Aqua-15: Maintain Flows in the Feather River, American River, and Trinity River Consistent with Existing Regulatory and Operational Requirements and Agreements.
Aesthetics and Visual Resources		
Impact Vis-1: Consistency with Guidelines for Visual Resources in the STNF LRMP (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Vis-1: Amend the STNF LRMP to Include Revised VQOs for developments at Turntable Bay area.
Impact Vis-2: Degradation and/or Obstruction of a Scenic View from Key Observation Points (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Vis-2: Minimize Construction-Related Visual Impacts on Scenic Views From Key Observation Points.
Impact Vis-3: Generation of Increased Daytime Glare and/or Nighttime Lighting (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Vis-3: Minimize or Avoid Visual Impacts of Daytime Glare and Nighttime Lighting.

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Transportation and Traffic		
Impact Trans-1: Short-Term and Long-Term Increases in Traffic in the Primary Study Area in Relation to the Existing Traffic Load and Capacity of the Street System	CP1 – CP5	Mitigation Measure Trans-1: Prepare and Implement a Traffic Control and Safety Assurance Plan.
Impact Trans-2: Adverse Effects on Access to Local Streets or Adjacent Uses in the Primary Study Area	CP1 – CP5	Mitigation Measure Trans-2: To Reduce Effects on Local Access, Implement Mitigation Measure Trans-1: Prepare and Implement a Traffic Control and Safety Assurance Plan
Impact Trans-4: Adverse Effects on Emergency Access in the Primary Study Area	CP1 – CP5	Mitigation Measure Trans-4: To Reduce Effects on Emergency Access, Implement Mitigation Measure Trans-1: Prepare and Implement a Traffic Control and Safety Assurance Plan
Impact Trans-5: Accelerated Degradation of Surface Transportation Facilities in the Primary Study Area	CP1 – CP5	Mitigation Measure Trans-5: Identify and Repair Roadway Segments Damaged by the Project.
Utilities and Service Systems		
Impact Util-1: Damage to or Disruption of Public Utility and Service Systems Infrastructure (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Util-1: Implement Procedures to Avoid Damage to or Temporary Disruption of Service.
Impact Util-2: Utility Infrastructure Relocation or Modification (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure Util-2: Adopt Measures to Minimize Infrastructure Relocation Impacts.
Public Services		
Impact PS-1: Disruption of Public Services (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure PS-1: Coordinate and Assist Public Services Agencies.
Impact PS-2: Degraded Level of Public Services (Shasta Lake and Vicinity and Upper Sacramento River)	CP1 – CP5	Mitigation Measure PS-2: Provide Support to Public Services Agencies.
Power and Energy		
No mitigation measures proposed.		
Environmental Justice		
No mitigation measures proposed.		

Table 5-9. Summary of Proposed Mitigation Measures for Comprehensive Plans (contd.)

Resource Topic/Impact	Alternative	Mitigation Measure
Wild and Scenic Rivers Considerations for McCloud River		
Impact WASR-3: Effects to McCloud River Wild Trout Fishery, as Identified in the California Public Resources Code, Section 5093.542	CP1 – CP5	Mitigation Measure WASR-3: Develop and Implement a Comprehensive Multi-scale Fishery Protection, Restoration and Improvement Program for the Lower McCloud River Watershed.
Impact WASR-4: Effects to McCloud River Free-Flowing Conditions, as Identified in the California Public Resources Code, Section 5093.542	CP1 – CP5	Mitigation Measure WASR-4: Implement Protection, Restoration, and Improvement Measures to Benefit Hydrologic Functions Within the Lower McCloud River Watershed.

Key:
Ag = Agriculture and Important Farmlands
AQ = Air Quality and Climate
Aqua = Fisheries and Aquatic Ecosystems
BLM = U.S. Bureau of Land Management
BMP = best management practice
Bot = Botanical Resources and Wetlands
CDFW = California Department of Fish and Wildlife
CP – Comprehensive Plan
CRPR = California Rare Plant Rank
Culture = Cultural Resources
CVP = Central Valley Project
Delta = Sacramento-San Joaquin Delta
Geo = Geology, Geomorphology, Minerals, and Soils
Haz = Hazards and Hazardous Materials and Waste
LU = Land Use Planning
MSCS = Multi-Species Conservation Strategy
MOA = Memorandum of Understanding
NHPA = National Historic Preservation Act
Noise = Noise and Vibration
PA = Programmatic Agreement
PS = Public Services
Rec = Recreation and Public Access
Socio = Socioeconomics, Population, and Housing
SWP = State Water Project
TBD = to be determined
Trans = Transportation and Traffic
USFS = U.S. Forest Service
Util = Utilities and Service Systems
Vis = Aesthetics and Visual Resources
Wild = Wildlife Resources
WQ = Water Quality

The increased area of inundation for CP1 is about 1,110 acres. This equates to an average increase in the lateral zone of about 21 feet. An example of the extent of inundation for the 6.5-foot dam raise (as well as 12.5-foot and 18.5-foot dam raises) is shown in Figure 5-8. The figure shows increased inundation of the Sacramento River arm at the community of Lakeshore, considering proposed protective dikes and embankments. Lakeshore is the most populated area around the lake. Because of the gently sloping shoreline adjacent to Lakeshore, this area is representative of the maximum lateral increase in inundation that could be expected with dam raises up to 18.5 feet. The community of Sugarloaf would also be impacted.

The duration of inundation at given drawdown levels (e.g., 10 feet from top of full pool) would be similar to existing conditions. Water would inundate the highest levels of the reservoir for periods ranging from several days to about 1 month. Much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, much of the remaining vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the flatter slopes because of the infrequent inundation.

The McCloud River is an area of specific interest. California Public Resources Code 5093.542 (c) and (d) may limit State involvement in studies to enlarge Shasta Dam and Reservoir if that action could have an adverse effect on the free-flowing conditions of the McCloud River or its wild trout fishery. Figure 5-9 illustrates the estimated increase in area of inundation on the McCloud River upstream from the McCloud Bridge for CP1 (6.5-foot dam raise). As shown in Figure 5-9, raising Shasta Dam 6.5 feet would result in inundating an additional 1,470 lineal feet (about 9 acres) of the lower McCloud River compared to existing conditions. Raising Shasta Dam 18.5 feet would result in inundating an additional 3,550 lineal feet (about 27 acres) of the lower McCloud River, compared to existing conditions. This represents a maximum of about 3 percent of the 24-mile-reach of river between the McCloud Bridge and McCloud Dam, which controls flows on the river.

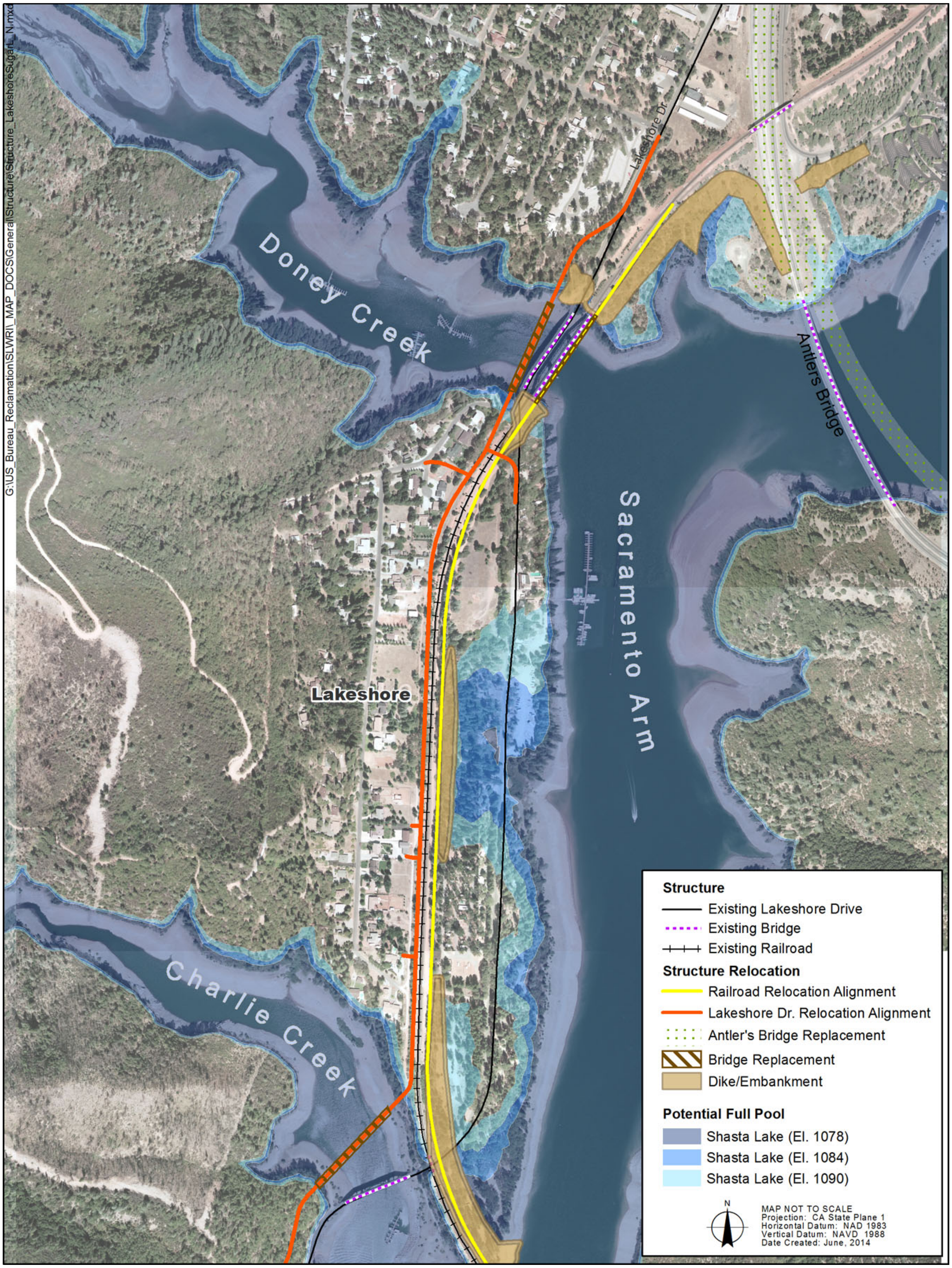


Figure 5-8. Estimated Maximum Inundation in the Lakeshore Area for Dam Raises of 6.5 Feet, 12.5 Feet, and 18.5 Feet

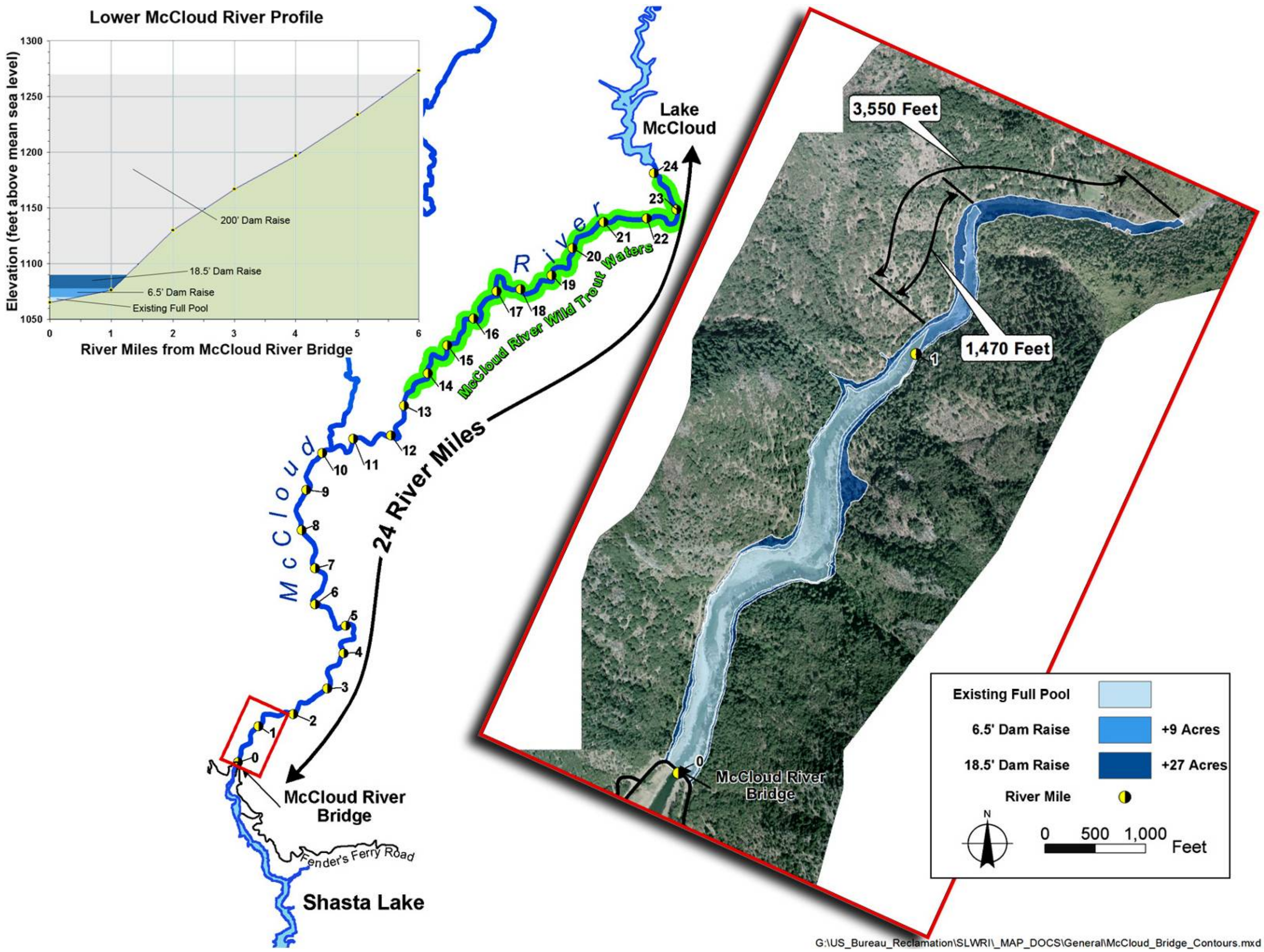


Figure 5-9. McCloud River Maximum Inundation for 6.5-foot and 18.5-foot Dam Raises

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP1 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation, and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP1, approximately 355 and 529 historic sites are within the inundation zone and fluctuation, respectively. The local Native American community has also identified several locations they consider to be sacred with potential for inundation under CP1; notable among these are the Winnemem Wintu locations Puberty Rock and the doctoring pools near Nawtawaket Creek. Although Puberty Rock would still be accessible for portions of the year, when lake levels are lower, CP1 would increase the frequency of inundation. Effects to historic properties are regulated under Section 106 of the National Historic Preservation Act, requiring measures to avoid, minimize, or mitigate adverse effects. The Winnemem Wintu will have the opportunity to participate, and continue to provide input, through the Section 106 process as an invited consulting party, and through the NEPA process.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related effects are also anticipated in the primary study area.

Upper Sacramento River Potential effects on flow and stages of the upper Sacramento River from this and other comprehensive plans would be minimal. Included in Figure 5-10 is an estimate of the percent change in river flows at Bend Bridge near Red Bluff for this and other dam raise scenarios under average, wet, and dry year conditions. Figures 5-11, 5-12, and 5-13 show CalSim-II simulated Sacramento River flows below Keswick Dam, above RBPP, and below Stony Creek, respectively, under wet, above- and below-normal, and dry and critical year conditions for the No-Action Alternative, compared to CP1 and CP4. As can be seen, during most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. Also, flows and stages would increase slightly from June through November. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. During dry periods, however, there are few to no changes in water flows or changes during the winter and spring periods. Potential noticeable changes in river flows and stages diminish rapidly downstream from the RBPP. This is primarily because of the significant amount of tributary inflows, especially from the Feather River system.

No effects on cultural resources are expected to occur in the upper Sacramento River region.

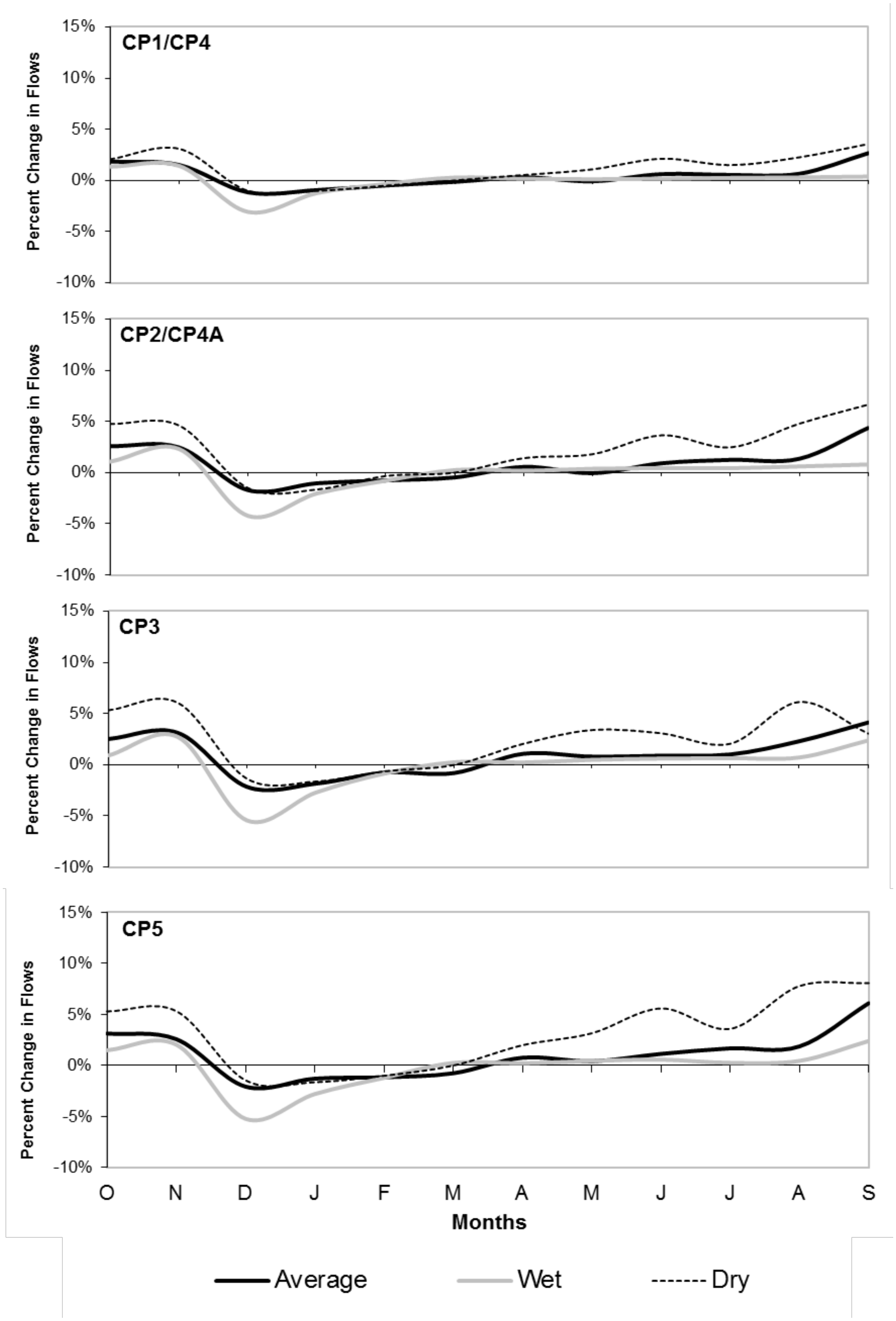
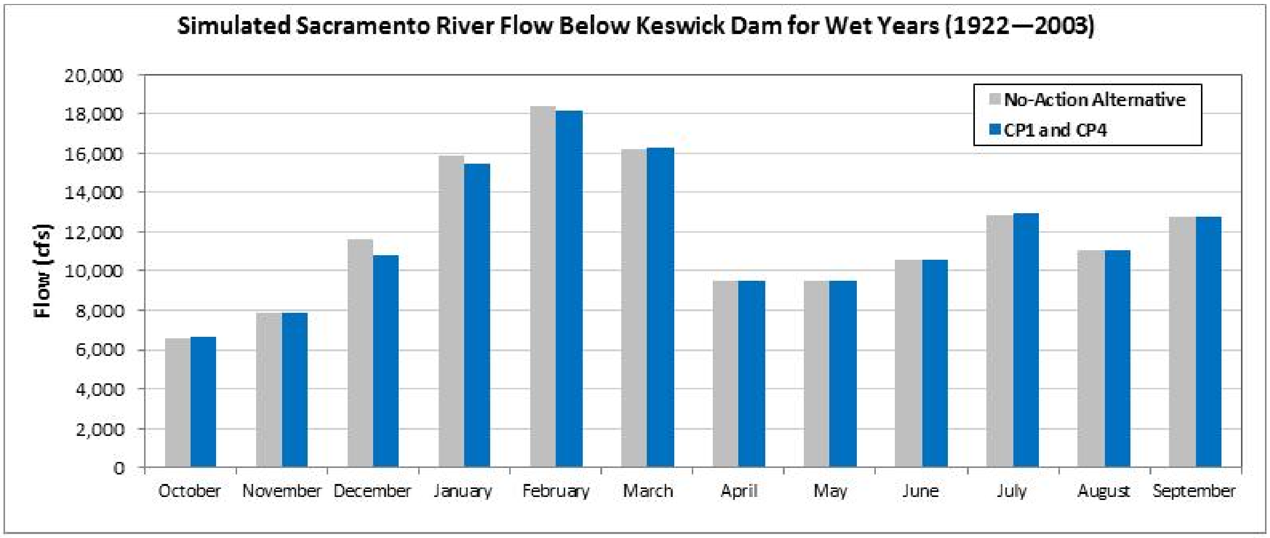
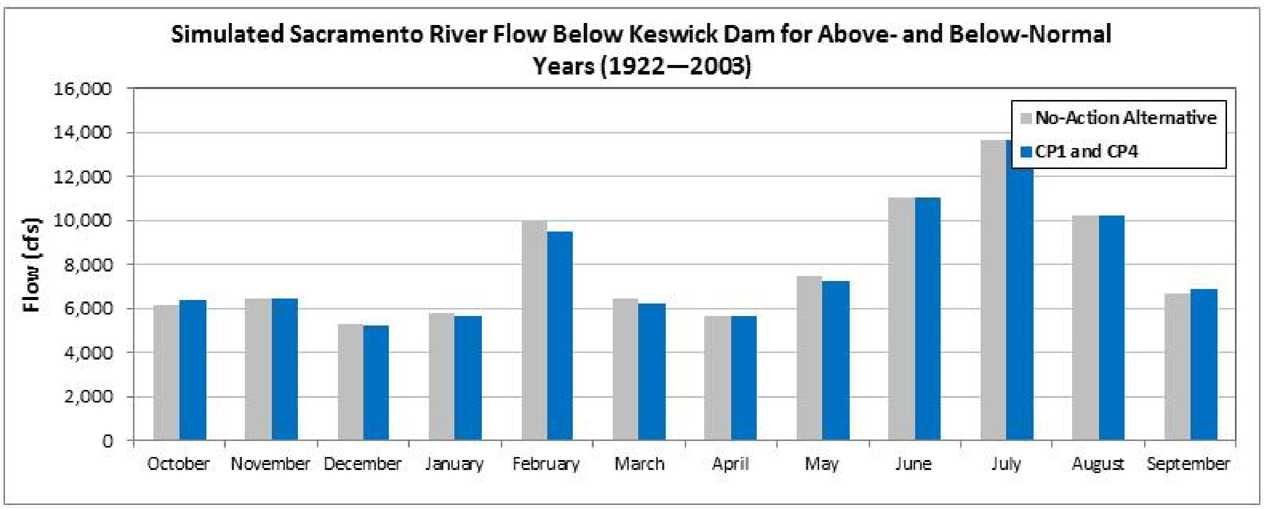


Figure 5-10. Percent Change in Simulated Flows at Bend Bridge for Average, Dry, and Wet Year Conditions





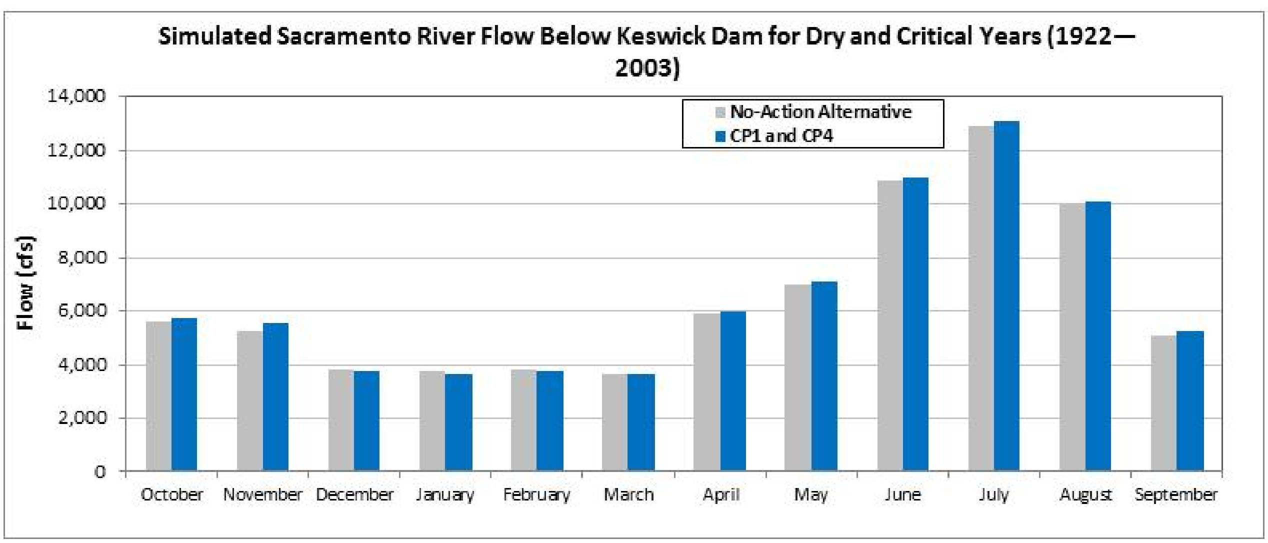


Figure 5-11. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP1, and CP4

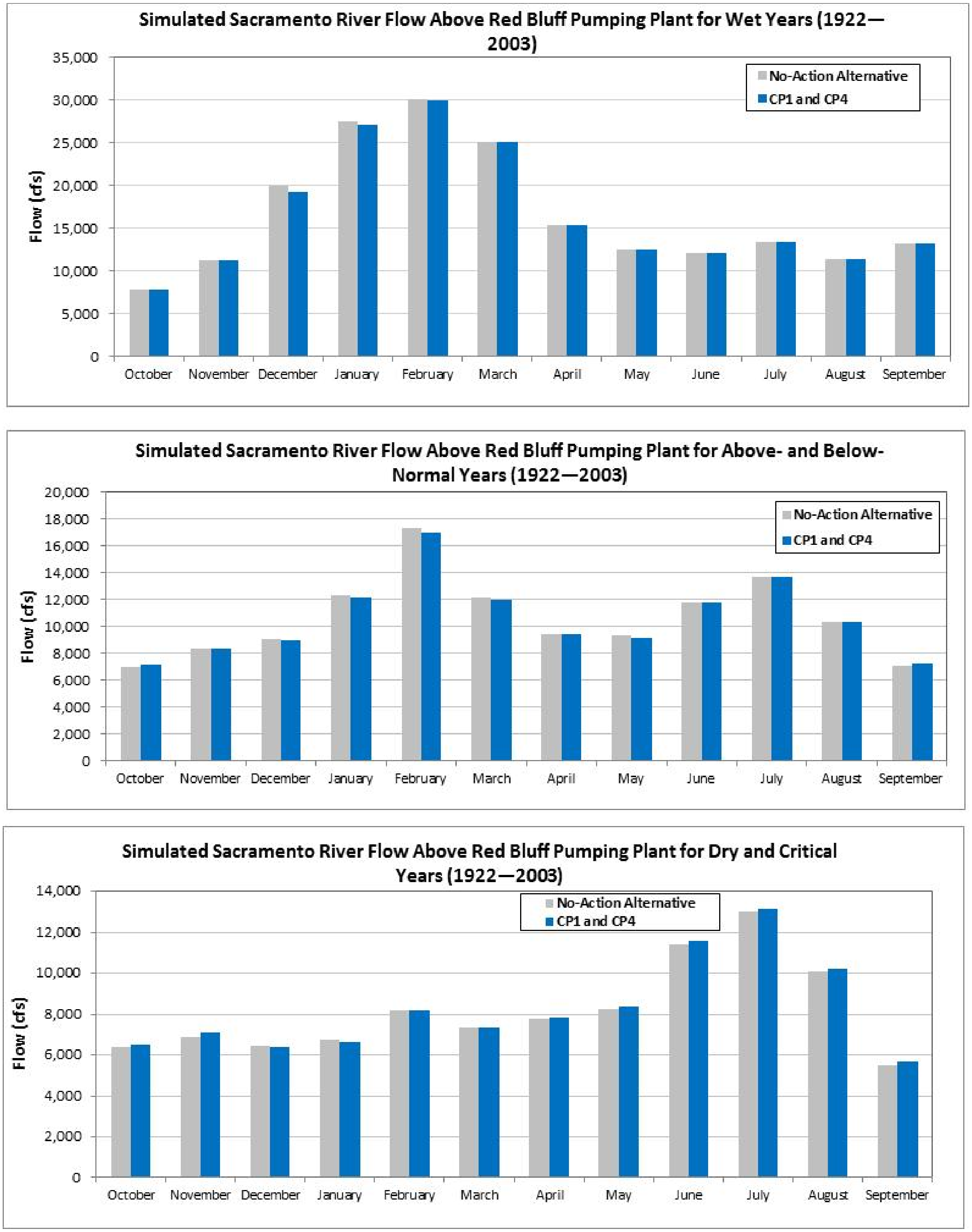
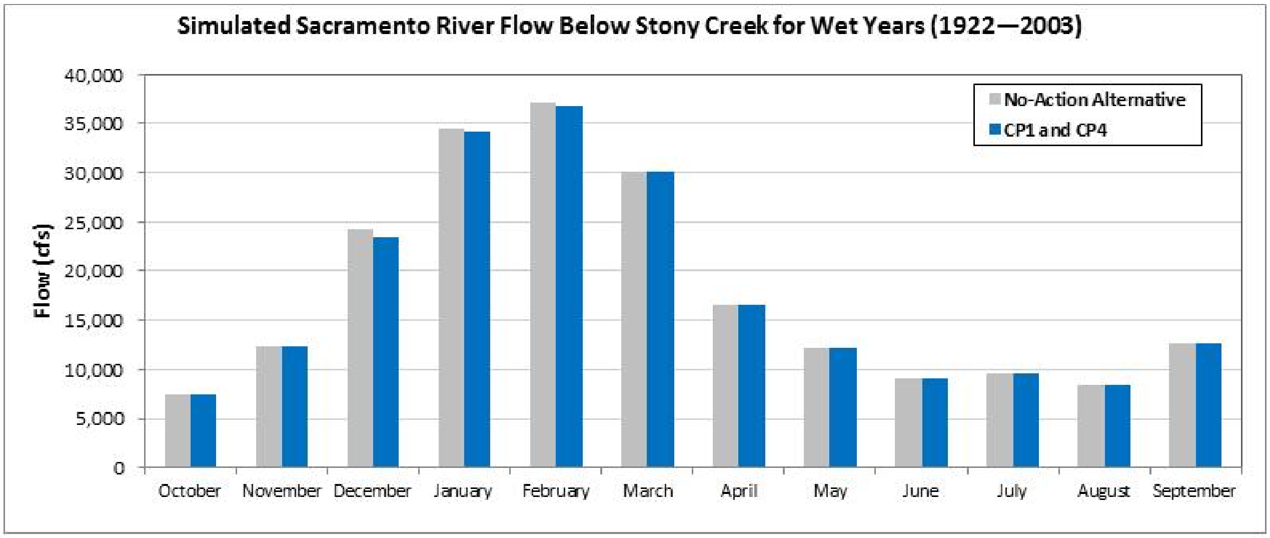
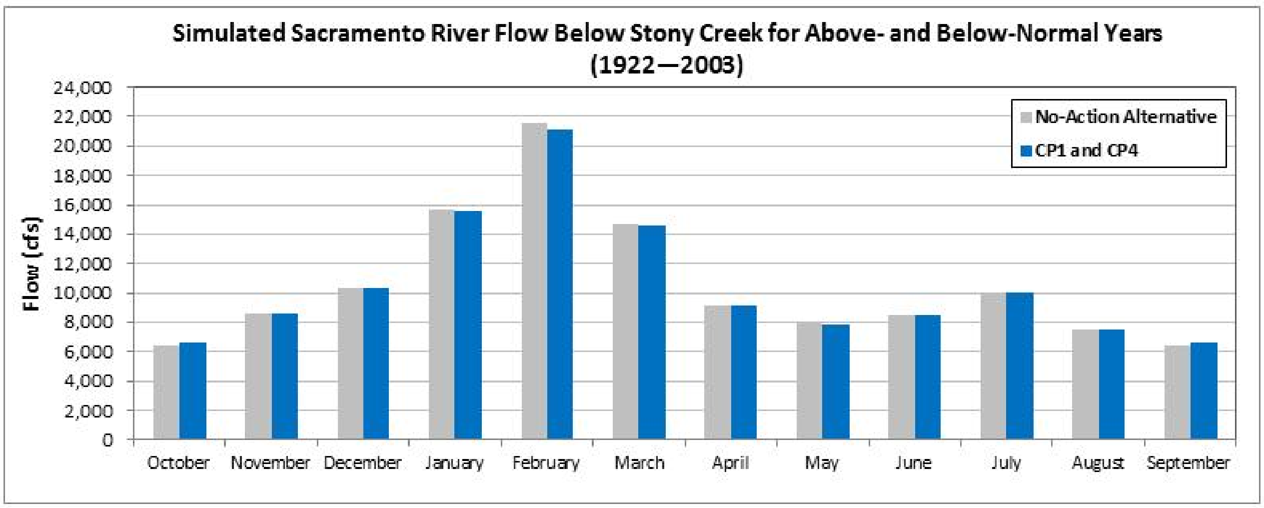


Figure 5-12. Sacramento River Flow Above Red Bluff Pumping Plant in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP1, and CP4





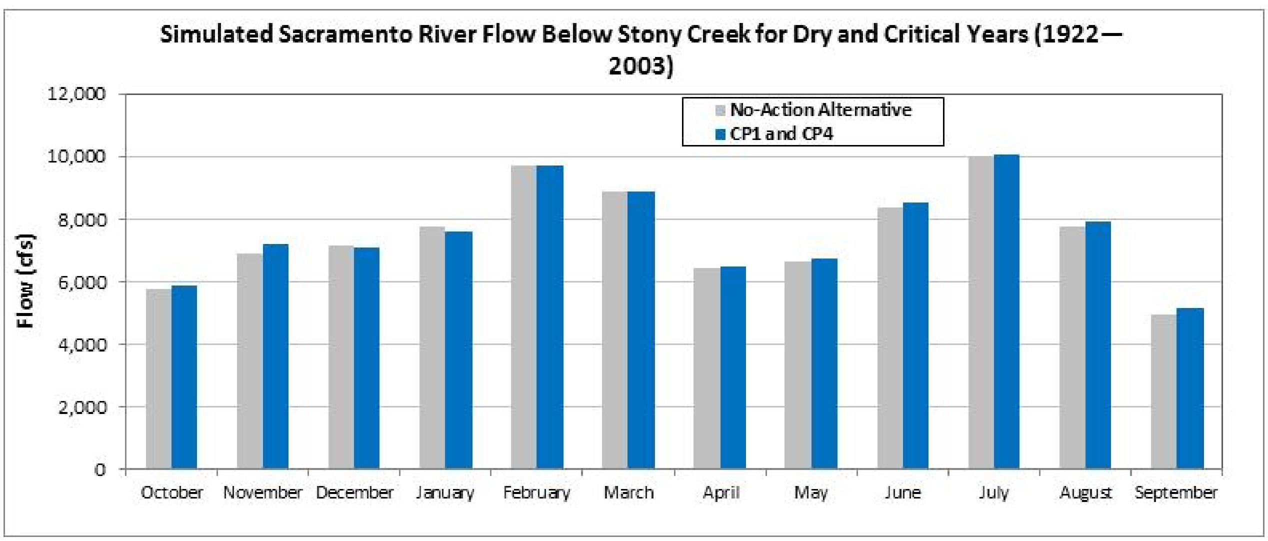


Figure 5-13. Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP1, and CP4

Changes in river flows and stages may impact geomorphic conditions along the river, existing riparian vegetation, and other wildlife resources. As mentioned above, the changes in temperatures and flows are, however, expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm-water species in the Sacramento River. This impact is not expected to be significant.

CP2 –12.5-Foot Dam Raise, Anadromous Fish and Water Supply Reliability

CP2 consists primarily of enlarging Shasta Dam by raising the crest 12.5 feet and enlarging the reservoir by 443,000 acre-feet. Major features of CP2 are shown in Figure 5-3 and summarized in Table 5-6.

Major Components of CP2

CP2 includes the following major components:

- Raising Shasta Dam and appurtenant facilities by 12.5 feet.
- Implementing the set of eight common management measures described above.
- Implementing the common environmental commitments described above.

A dam raise of 12.5 feet was chosen because it represents a midpoint between the likely smallest dam raise considered and the largest practical dam raise that would not require relocating the Pit River Bridge. By raising Shasta Dam from a crest elevation of 1,077.5 feet to 1,090.0 feet (based on NGVD29), CP2 would increase the height of the reservoir's full pool by 14.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to the modifications proposed under CP1. This increase in full pool height would add approximately 443,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would increase from 4.55 MAF to 5.0 MAF. Figure 5-4 shows the increase in surface area and storage capacity for CP2.

Under CP2, the additional storage in Shasta Reservoir would be used to increase water supply reliability and to expand the cold-water pool for downstream anadromous fisheries. The existing TCD would also be extended for efficient use of the expanded cold-water pool. Operations for water supply, hydropower, and environmental and other regulatory requirements would be similar to existing operations, except during dry and critical years when a portion of the increased storage in Shasta Reservoir would be reserved to specifically focus on increasing M&I deliveries. In dry years, 120,000 acre-feet of the 443,000 acre-feet increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. In critical years, 60,000 acre-feet of the increased storage capacity would be reserved for increasing M&I deliveries.

As described for CP1, this plan would include the potential to revise flood control operational rules, which could potentially reduce flood damage and benefit recreation.

Potential Benefits of CP2

Major potential benefits of CP2, related to the planning objectives and broad public services, are described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors affecting anadromous fish survival in the Sacramento River. CP2 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critical water years. This would be accomplished by raising Shasta Dam 12.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBPP. Hence, the most significant benefits to anadromous fish would occur upstream from the RBPP. It is estimated that improved water temperature and flow conditions under CP2 could result in an average annual increase in the Chinook salmon population of about 379,200 out-migrating juvenile Chinook salmon.

Increase Water Supply Reliability CP2 would increase water supply reliability by increasing water supplies for CVP and SWP irrigation and M&I deliveries. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. CP2 would help reduce estimated future water shortages by increasing the reliability of dry and critical year water supplies for agricultural and M&I deliveries by at least 77,800 acre-feet per year and average annual deliveries by about 51,300 acre-feet per year. As shown in Table 5-7, the majority of increased dry and critical year water supplies, 67,100 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts on agricultural and urban areas resulting from water shortages. Under CP2, approximately $2.6 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 87 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities. Other power benefits include additional capacity (i.e., the rate at which power can be generated) and ancillary services, which provide the ability to manage the electric grid in a reliable manner.

Maintain and Increase Recreation Opportunities CP2 includes features to, at minimum, maintain the existing recreation capacity at Shasta Lake. Although CP2 does not have specific features to further increase recreation capacity, benefits to the water-oriented recreation experience at Shasta Lake would likely occur because of the increase in average lake surface area, reduced drawdown during the recreation season, and modernization of recreation facilities. The maximum surface area of the lake would increase by about 1,900 acres (6 percent), from 29,700 acres to about 31,600 acres. The average surface area of the lake during the recreation season from May through September would increase by about 1,300 acres (5 percent), from 23,900 acres to 25,200 acres. There is also limited potential to provide additional benefits to recreation by allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other Planning Objectives CP2 could also provide benefits related to flood damage reduction, ecosystem restoration, and water quality, as described for CP1, but to a greater extent because of increased capacity and associated overall system flexibility.

Additional Broad Public Benefits Additional broad public benefits of CP2 obtained through pursuing project objectives are summarized in Table 5-8. Broad public benefits for CP2 are similar to CP1 but amplified due to the higher dam raise further enlarging system capacity and the facility upgrades associated with additional relocations.

Construction for CP2

Construction activities associated with physical features under CP2 would include land-based construction activities associated with the following:

- Clearing vegetation from portions of the inundated reservoir area
- Constructing the dam raise, appurtenant structures, reservoir area dikes, and railroad embankments
- Relocating roadways, bridges, recreation facilities, utilities, and miscellaneous minor infrastructure

Construction activities for CP2 are described in detail in the Engineering Summary Appendix.

Operations and Maintenance for CP2

Operations under CP2 are governed by the same regulatory constraints as described for CP1. Similar to CP1, the additional storage would be retained to increase water supply reliability and to expand the cold-water pool in Shasta Reservoir for fisheries benefits. Shasta Dam operational guidelines would continue unchanged, except during dry years and critical years, when 120,000 acre-feet and 60,000 acre-feet, respectively, of the 443,000 acre-feet increased storage capacity in Shasta Reservoir would be operated primarily to increase M&I deliveries. Operations targeting increased M&I deliveries were based on existing and anticipated future demands, operational priorities, and facilities of the SWP. For CP2, existing water quality and temperature requirements would typically be met in most years; therefore, additional water in storage would be released primarily for water supply purposes. Accordingly, minimal increases in flow would be expected in months when Delta exports were constrained, or when flow was not usable for water supply purposes.

In comparison to current operations, CP2 would store some additional flows behind Shasta Dam during periods when downstream needs would have already been met, but flows would have been released because of storage limitations. The resulting increase in storage would be released downstream when there were opportunities for beneficial use of the water, either to meet water supply reliability demands or to improve Reclamation's abilities to meet its environmental objectives. The additional water in storage would also expand the cold-water pool and increase end-of-September carryover storage in Shasta Reservoir, increasing the ability of Shasta Dam to improve water temperatures for anadromous fish in the upper Sacramento River.

Conversely, if water in storage were insufficient to meet all of the project purposes, the first increment to be reduced would be deliveries to water service contractors. Releases from Shasta Dam under CP2 would typically increase in the summer months, corresponding with the periods of greatest agricultural demands. Similarly, releases would be reduced in the winter months, when the increased storage space could be used to capture additional runoff rather than releasing water to the downstream river, as would occur with Shasta Reservoir's current operations.

Maintenance of facilities related to the proposed dam and reservoir enlargement would be similar to maintenance activities currently conducted at Shasta Dam and Reservoir.

Operation of pumping facilities downstream from Shasta Dam would vary slightly from current operations and would result in higher costs. In addition, Reclamation would provide in-kind power to offset reduced generation at Pit 7 Dam and related facilities.

Potential Primary Effects of CP2

Following is a summary of the potential environmental effects of CP2. Potential environmental effects are generally comparable between comprehensive plans; some adverse effects would be exacerbated by larger dam raises and the associated scale of those effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Proposed mitigation measures to address potential adverse impacts of CP2 are summarized in Table

5-9. As mentioned, a detailed discussion of potential effects and proposed mitigation measures are included in Chapters 4 through 25 of the EIS.

Shasta Lake Area As with CP1, the primary long-term effects of this comprehensive plan would be due to the increased water surface elevations and inundation area. The dam raise scenario under CP2 is greater than under CP1; therefore, anticipated effects under CP2 are expected to be slightly greater. As with the above plan, raising the full pool of the lake would cause direct effects due to higher water levels, and/or indirect impacts related to facility modifications and relocations.

CP2 includes modifying two bridges and replacing six other bridges, inundating a number of small segments of existing paved and nonpaved roads, and relocating a number of potable water facilities, wastewater facilities, gas and petroleum facilities, and power distribution and telecommunications facilities. A number of recreation facilities would also be impacted, including campgrounds, marinas, resorts, boat ramps, day-use areas, and trails. Approximately 21 segments of roadway would be relocated, including portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road. Embankments would be constructed to protect I-5 at Lakeshore and UPRR at Bridge Bay. Any potential real estate acquisitions or necessary relocations of displaced parties would be accomplished under Public Law 91-646.

With CP2, Shasta Reservoir would fill to the new full pool storage of 5.0 MAF at a frequency similar to without-project conditions. On the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent or its current capacity in about 81 percent of the years over the 82-year period of analysis of the CalSim-II model. Figure 5-5 shows an exceedence probability relationship of maximum annual storage in Shasta Reservoir for this and other dam raises. With this alternative, Shasta Reservoir would fill to 80 percent of the new capacity in about 74 percent of the years. Accordingly, annual operations in the reservoir would generally mirror existing operations, but the water surface in the reservoir would be about 12.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. Figure 5-14 shows the changes from without-project conditions for CP2 for a representative period of 1972 through 2003.

The increased area of inundation for CP2 is about 1,900 acres. As with the previous plan, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

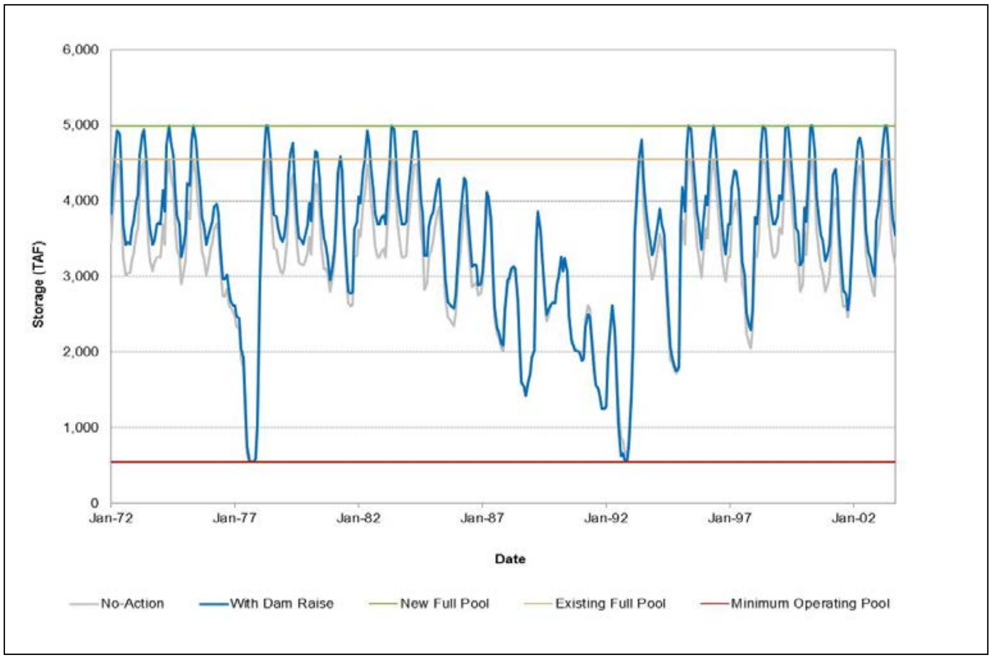


Figure 5-14. Simulated Shasta Reservoir Storage from 1972 to 2003 for the No-Action Alternative and CP2

Raising Shasta Dam 12.5 feet would result in inundating an additional 2,740 linear feet (about 18 acres) of the lower McCloud River. This represents about 2 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP2 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation, and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP2, approximately 371 and 529 historic sites are within the inundation zone and fluctuation, respectively. Effects to traditional cultural properties and sacred sites under CP2 would be similar to CP1.

Although recreation would generally improve under this plan, water in the lake would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 14.5 feet greater than under existing conditions. In addition, clearances for boat traffic under the Pit River Bridge would be restricted to the north end of the bridge during periods of high reservoir levels (at or near full pool). This condition would typically occur in the late spring (May to June) in about 1 out of 3 years, and could last several days to a week. The estimated minimum clearance at the new full pool would be about 20 feet between Piers 6 and 7. This would not be expected to significantly impact boating on the lake.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related impacts are also anticipated in the primary study area.

Upper Sacramento River As with the previous plan, potential effects on flow and stages of the upper Sacramento River from CP2 and other comprehensive plans would be minimal. Figures 5-15, 5-16, and 5-17 show CalSim-II simulated Sacramento River flows below Keswick Dam, RBPP, and Stony Creek, respectively, under wet, above- and below-normal, and dry and critical year conditions for the No-Action Alternative compared to CP2. During most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River would be relatively unchanged. Also, flows and stages would increase slightly from June through November. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. During dry periods, however, there are few to no changes in water flows or changes during the winter and spring periods. All potential noticeable changes in flows and stages would diminish rapidly downstream from the RBPP.

No effects on cultural resources are expected to occur in the upper Sacramento River region.

Similar to CP1, changes in river flows and stages may impact geomorphic conditions, existing riparian vegetation, and other wildlife resources of the upper Sacramento River. As mentioned above, the changes in temperatures and flows are expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered flow and temperature regime may adversely impact warm-water species in the Sacramento River. This effect is not expected to be significant.

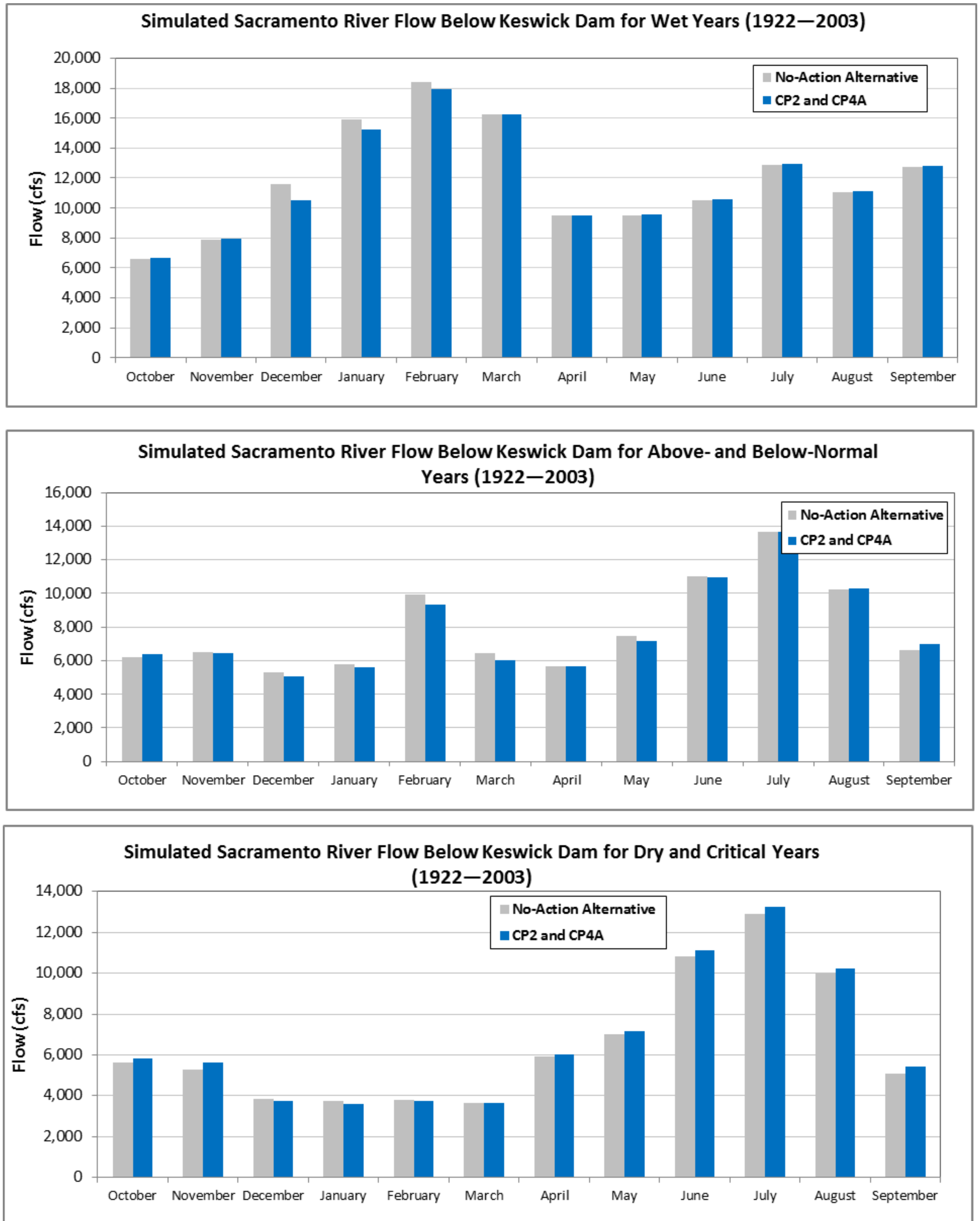


Figure 5-15. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP2, and CP4A

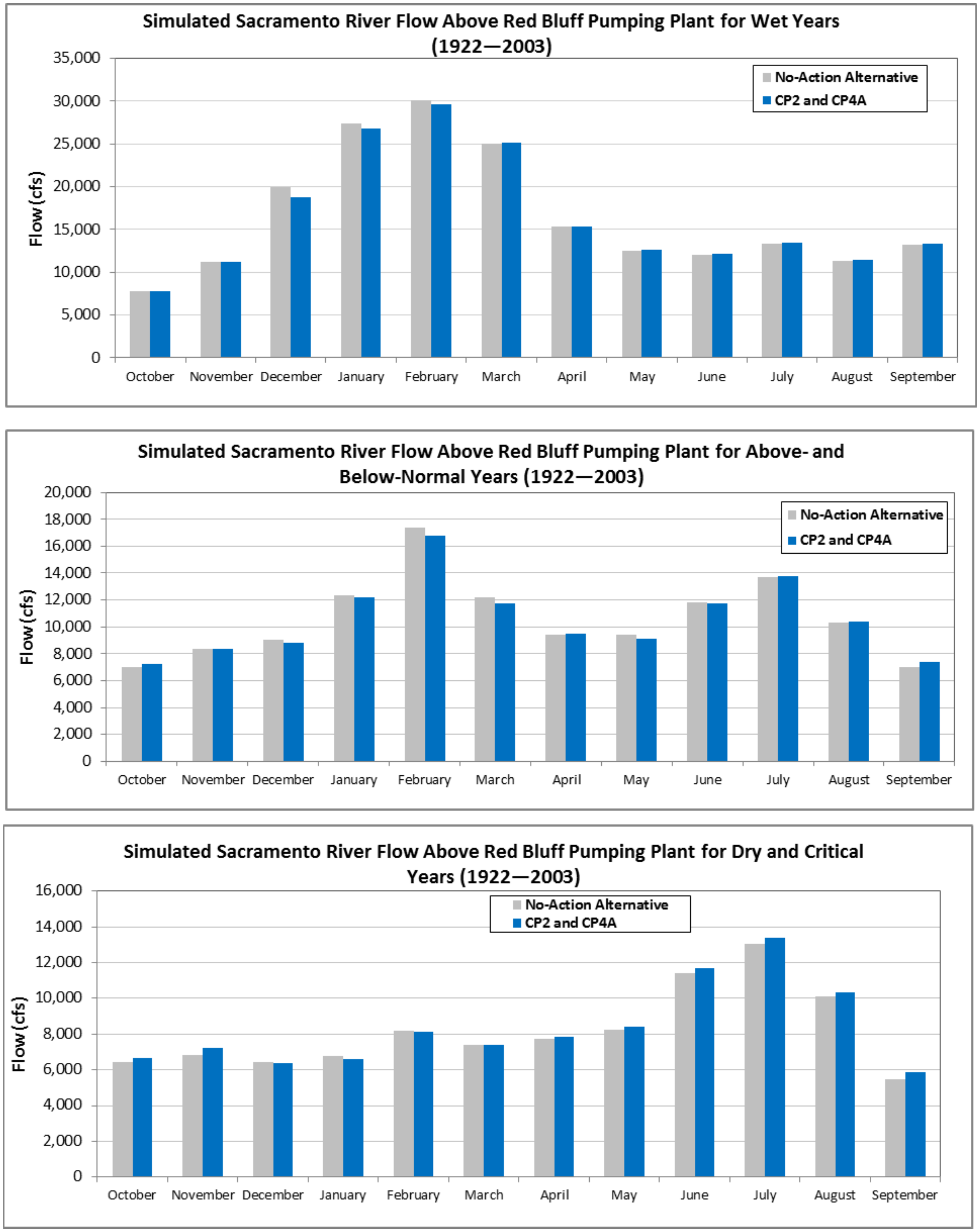


Figure 5-16. Sacramento River Flow Below Red Bluff Pumping Plant in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP2, and CP4A

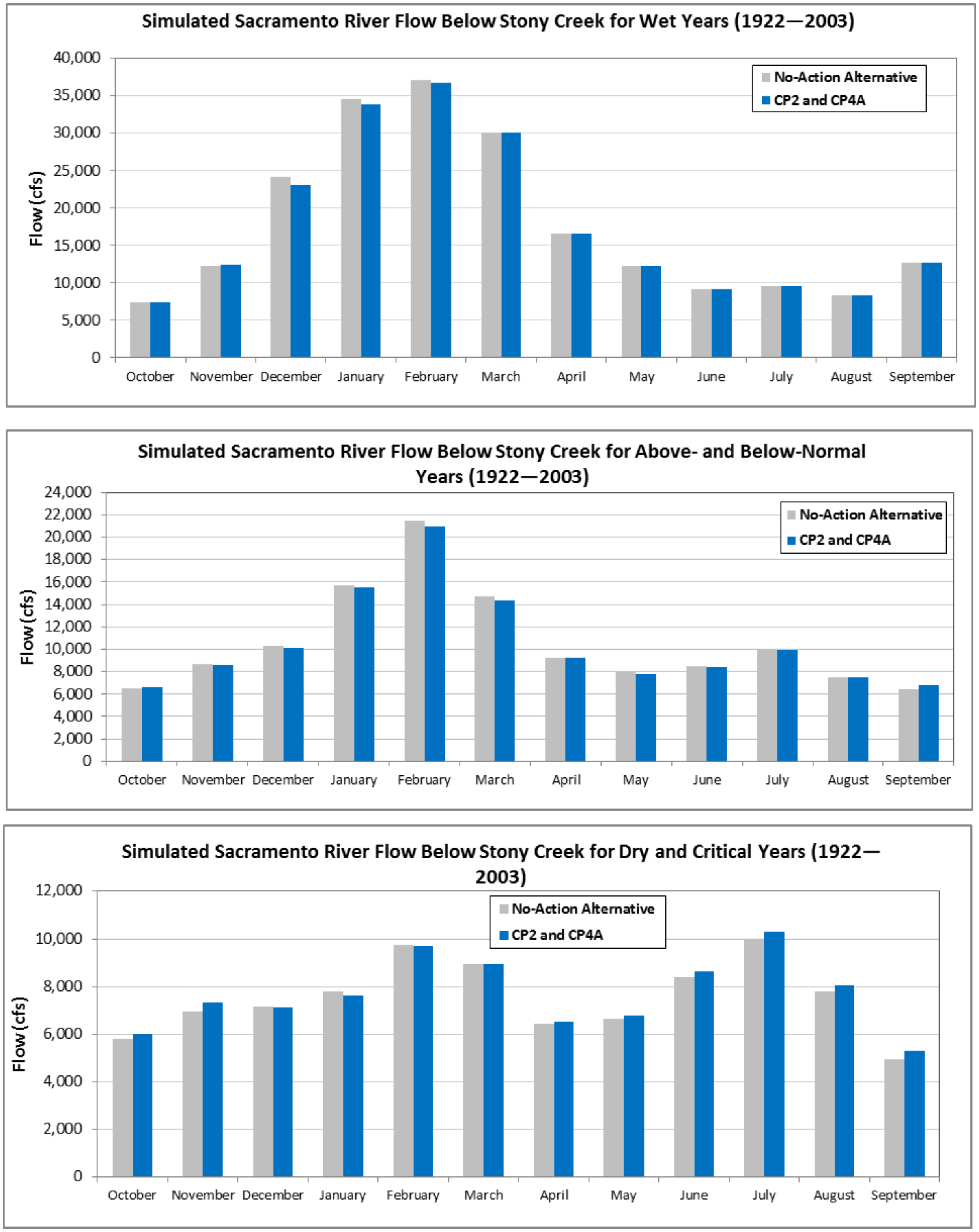


Figure 5-17. Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action, CP2, and CP4A

CP3 – 18.5-Foot Dam Raise, Agricultural Water Supply Reliability and Anadromous Fish Survival

CP3 consists primarily of enlarging Shasta Dam and Reservoir by raising the dam crest 18.5 feet and enlarging the reservoir by 634,000 acre-feet. Major features of CP3 are shown in Figure 5-3 and summarized in Table 5-6.

Major Components of CP3

Major components of this plan include the following:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Implementing the set of eight common management measures previously described.
- Implementing the common environmental commitments described above

By raising Shasta Dam 18.5 feet, from a crest elevation of 1,077.5 feet to 1,096.0 feet (based on NGVD29), CP3 would increase the height of the reservoir full pull by 20.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to the modifications proposed under CP1. This increase in full pool height would add approximately 634,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would increase from 4.55 MAF to 5.19 MAF. Although higher dam raises are technically and physically feasible, 18.5 feet is the largest dam raise that would not require extensive and very costly reservoir area relocations such as relocating the Pit River Bridge, I-5, and the UPRR tunnels, as shown in Figure 5-18. Raising the dam 18.5 feet would provide the minimum clearance required (4 feet) at the south end of the Pit River Bridge, while still providing more than 14 feet of clearance at the north end of the bridge. Figure 5-4 shows the increase in surface area and storage capacity for CP3.

Because CP3 focuses on increasing agricultural water supply reliability and anadromous fish survival, none of the increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. Operations for water supply, hydropower, and environmental and other regulatory requirements would be similar to existing operations. The additional storage would be retained for water supply reliability and to expand the cold-water pool for downstream anadromous fisheries. The existing TCD would also be extended for efficient use of the expanded cold-water pool.

As described for the above plans, this plan would include the potential to revise flood control operational rules, which could reduce the potential for flood damage and benefit recreation.

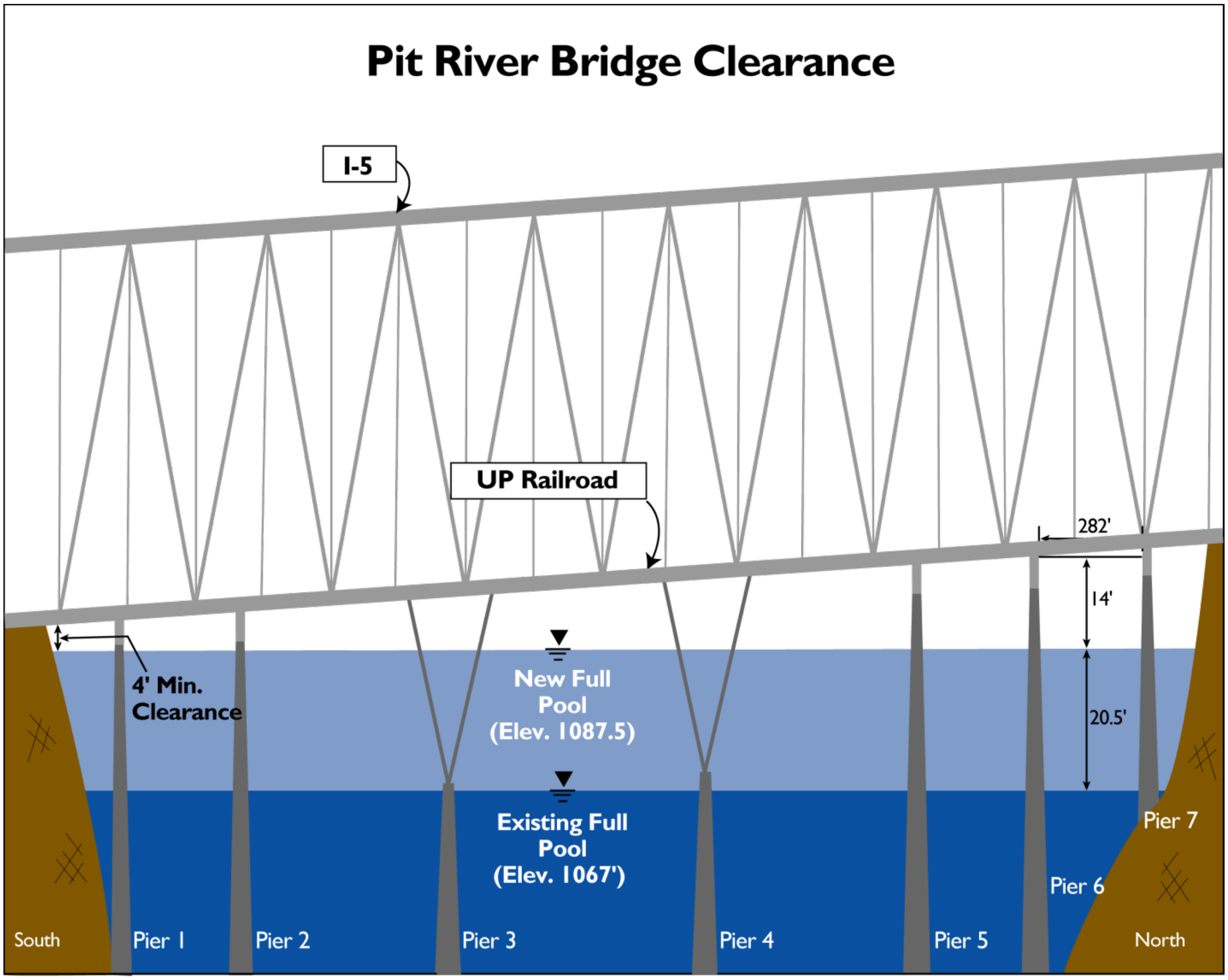


Figure 5-18. Minimum Clearance for Boat Traffic at Pit River Bridge, Full Pool with 18.5-foot Dam Raise

Potential Benefits of CP3

Major potential benefits of CP3, related to the planning objectives and broad public services, are described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors affecting anadromous fish survival in the Sacramento River. CP3 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critical water years. This would be accomplished by raising Shasta Dam 18.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBPP. Hence, the most significant water temperature benefits to anadromous fish would occur upstream from the RBPP. It is estimated that improved water temperature and flow conditions under CP3 could result in an average annual increase in the Chinook salmon population of about 207,400 out-migrating juvenile fish.

Increase Water Supply Reliability CP3 would increase water supply reliability by increasing water supplies for CVP irrigation and M&I deliveries, primarily during drought periods. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. CP3 would help reduce estimated future water shortages by increasing the reliability of dry and critical year water supplies for agricultural deliveries by at least 63,100 acre-feet per year and average annual deliveries by about 61,700 acre-feet per year. As shown in Table 5-7, almost half of the increased dry and critical year water supplies, 28,000 acre-feet, would be for south-of-Delta agricultural deliveries, with the remainder for north-of-Delta agricultural deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP3, approximately $3.1 million would be allocated over an initial 10-year period to fund agricultural water conservation programs, focused on agencies benefiting from increased project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 86 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities. Other power benefits include additional capacity (i.e., the rate at which power can be generated) and ancillary services, which provide the ability to manage the electric grid in a reliable manner.

Maintain and Increase Recreation Opportunities CP3 includes features to, at a minimum, maintain the existing recreation capacity at Shasta Lake. Although CP3 does not include specific features to further increase recreation capacity, benefits to the water-oriented recreation experience at Shasta Lake would likely occur because of the increase in average lake surface area, reduced drawdown during the recreation season, and modernization of recreation facilities. The maximum surface area of the lake would increase by about 2,600 acres (9 percent), from 29,700 acres to about 32,300 acres. The average surface area of the lake during the recreation season from May through September would increase by about 2,000 acres (8 percent), from 23,900 acres to 25,900 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other Planning Objectives CP3 could also provide benefits related to flood damage reduction, ecosystem restoration, and water quality, as described for CP1, but to a greater extent because of increased capacity and associated overall system flexibility.

Additional Broad Public Benefits Additional broad public benefits of CP3 obtained through pursuing project objectives are summarized in Table 5-8. Broad public benefits for CP3 are similar to CP1 and CP2 but are amplified due to the higher dam raise further enlarging system capacity and facility upgrades associated with additional relocations.

Construction for CP3

Construction activities associated with physical features under CP3 would include land-based construction activities associated with the following:

- Clearing vegetation from portions of the inundated reservoir area
- Constructing the dam raise, appurtenant structures, reservoir area dikes, and railroad embankments
- Relocating roadways, bridges, recreation facilities, utilities, and miscellaneous minor infrastructure

Construction activities for CP3 are described in detail in the Engineering Summary Appendix.

Operations and Maintenance for CP3

Operations under CP3 are governed by the same regulatory constraints as described for CP1. Under CP3, Shasta Dam operational guidelines would continue unchanged, with the additional storage retained for agricultural water supply reliability and to expand the cold-water pool in Shasta Reservoir for fisheries benefits. Unlike CP1 and CP2, none of the increased storage space in Shasta Reservoir would be reserved for increasing M&I deliveries under CP3. Existing water quality and temperature requirements would be met in most years; therefore, additional water in storage would be released primarily for water supply purposes. Accordingly, minimal increases in flow would be expected in months when Delta exports were constrained, or when flow was not usable for water supply purposes.

In comparison to current operations, CP3 would store some additional flows behind Shasta Dam during periods when downstream needs would have already been met, but flows would have been released because of storage limitations. The resulting increase in storage would be released downstream when there were opportunities for beneficial use of the water, either to meet water supply reliability demands or to improve Reclamation's abilities to meet its environmental objectives. The additional water in storage would also expand the cold-water pool and increase end-of-September carryover storage in Shasta

Reservoir, increasing the ability of Shasta Dam to improve water temperatures for anadromous fish in the upper Sacramento River.

Conversely, if water in storage were insufficient to meet all of the project purposes, the first increment to be reduced would be deliveries to water service contractors. Releases from Shasta Dam under CP3 would typically increase in the summer months, corresponding with the periods of greatest agricultural demands. Similarly, releases would be reduced in the winter months, when the increased storage space could be used to capture additional runoff rather than releasing water to the downstream river, as would occur with Shasta Reservoir's current operations.

Maintenance of facilities related to the proposed dam and reservoir enlargement would be similar to maintenance activities currently conducted at Shasta Dam and Reservoir.

Operation of pumping facilities downstream from Shasta Dam would vary slightly from current operations and would result in higher costs. In addition, Reclamation would provide in-kind power to offset reduced generation at Pit 7 Dam and related facilities.

Potential Primary Effects of CP3

Following is a summary of potential environmental consequences of CP3. Potential environmental effects are generally comparable between comprehensive plans; some adverse effects would be exacerbated by larger dam raises and the associated scale of those effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Proposed mitigation measures to address potential adverse impacts of CP3 are summarized in Table 5-9. A detailed discussion of potential effects and proposed mitigation measures associated with raising Shasta Dam by 18.5 feet are included in Chapters 4 through 25 of the EIS.

Shasta Lake Area   As with the other comprehensive plans, the primary long-term effects of CP3 would be due to the increased water surface elevations and inundation area. The dam raise scenario under CP3 is greater than under CP1 or CP2; therefore, anticipated effects under CP3 are expected to be slightly greater. As with the above plan, raising the full pool of the lake would cause direct effects due to higher water levels, and/or indirect impacts related to facility modifications and relocations.

CP3 includes modifying two bridges and replacing six other bridges, inundating a number of small segments of existing paved and nonpaved roads, and relocating a number of potable water facilities, wastewater facilities, gas and petroleum facilities, and power distribution and telecommunications facilities. A number of recreation facilities would also be impacted, including campgrounds, marinas, resorts, boat ramps, day use areas, and trails. Approximately 30 segments of roadway would be relocated, including portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road. Embankments would be constructed to protect I-5 at Lakeshore and the UPRR at Bridge Bay. Any potential real estate acquisitions or necessary relocations of displaced parties would be accomplished under Public Law 91-646.

With CP3, Shasta Reservoir would fill to the new full pool storage capacity of 5.19 MAF at a frequency similar to without-project conditions. On the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent of its current capacity in about 81 percent of the years over the 82-year period of analysis of the CalSim-II model. Included in Figure 5-5 is an exceedence probability relationship of maximum annual storage in Shasta Lake for this and other dam raises. Under CP3, Shasta Reservoir would also fill to 80 percent of the new capacity in about 72 percent of the years. Accordingly, the annual operations in the reservoir would generally mirror existing operations, except the water surface in the lake would be about 18.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. Figure 5-19 shows the changes from without-project conditions for CP3 for a representative period of 1972 through 2003.

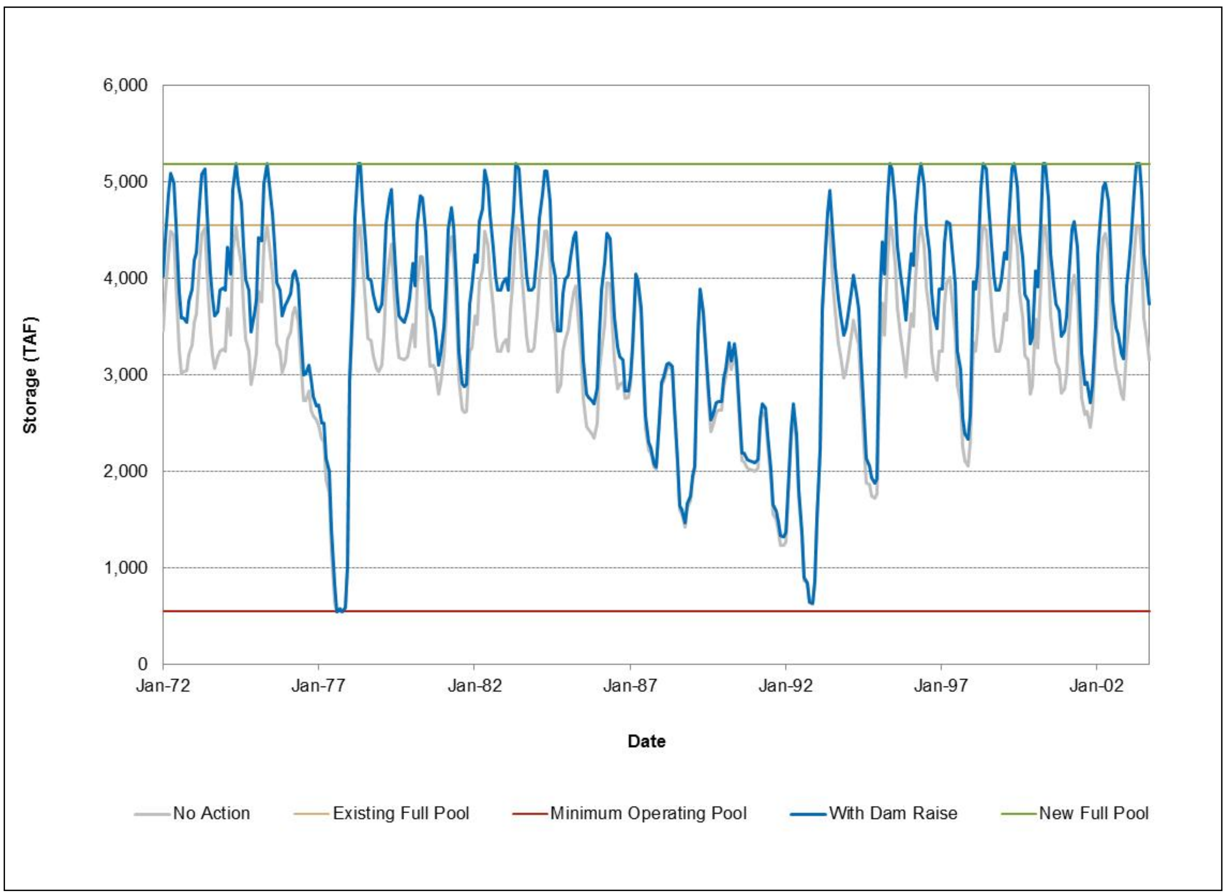


Figure 5-19. Simulated Shasta Reservoir Storage from 1972 to 2003 for the No-Action Alternative and CP3

The increased area of inundation for this plan is about 2,600 acres. As with the previous plans, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

As shown in Figure 5-9, raising Shasta Dam 18.5 feet would result in inundating an additional 3,550 linear feet (about 27 acres) of the lower McCloud River. This represents about 3 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

Although it is believed that recreation use would generally improve under this plan because of a larger lake surface area, water in the lake would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 20.5 feet greater than under existing conditions. During these periods, the drawdown zone could increase by about 50 linear feet. In addition, clearances for boat traffic under the Pit River Bridge would be restricted to the north end of the bridge during periods of high reservoir levels (at or near full pool). This condition would typically occur in the late spring (May to June) in about 1 out of 3 years, and could last several days to 1 or 2 weeks. Figure 5-18 illustrates that the minimum clearance at the new full pool would be about 14 feet between Piers 6 and 7. This could impact boating on the lake, as some houseboats exceed 16 feet in height. Since houseboating is a major recreational experience on Shasta Lake, especially around Memorial Day, restrictions on large boat traffic under the Pit River Bridge during maximum pool levels could adversely impact lake area boat rentals, marinas, and other recreation-dependent businesses.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP3 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP3, approximately 391 and 529 historic sites are within the inundation zone and fluctuation, respectively. Effects to traditional cultural properties and sacred sites under CP3 would be similar to CP1.

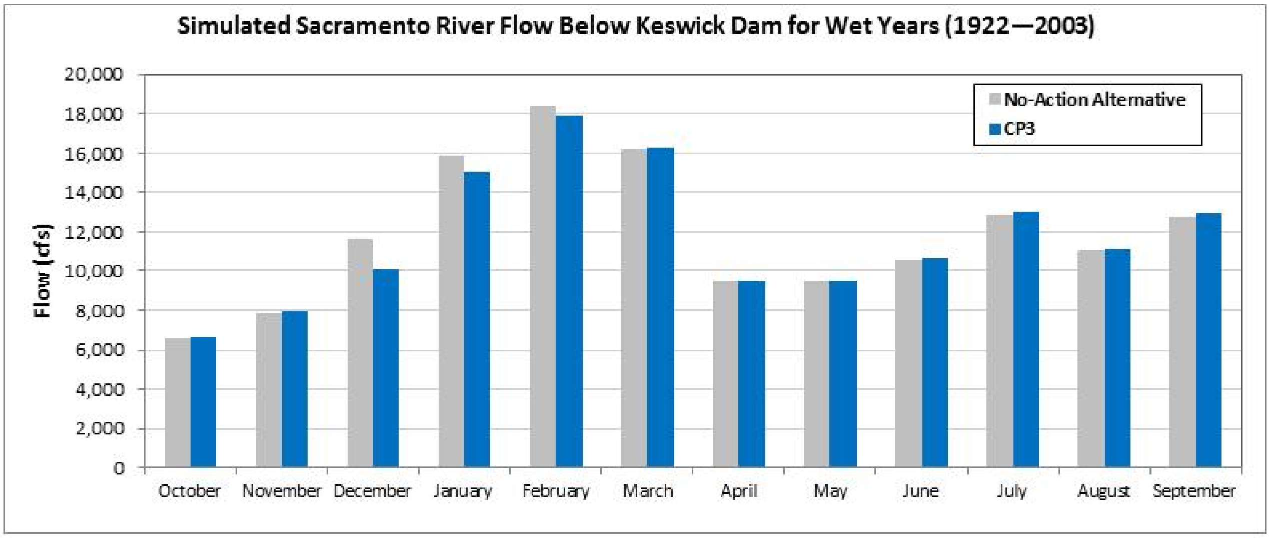
Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related impacts are also anticipated in the primary study area.

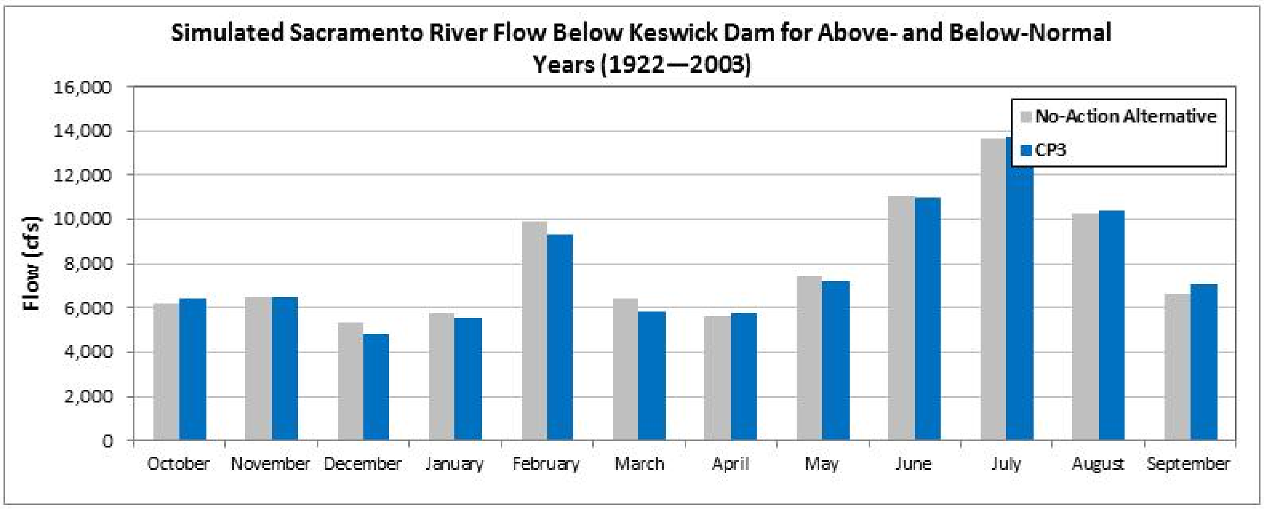
Upper Sacramento River As with the previous plan, potential effects on flow and stages of the upper Sacramento River from this and other comprehensive plans would be minimal. Figures 5-20, 5-21, and 5-22 show CalSim-II simulated Sacramento River flows below Keswick Dam, RBPP, and Stony

Creek, respectively, under wet, above- and below-normal, and dry and critical year conditions for the No-Action Alternative compared to CP3. During most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. Also, flows and stages would increase slightly from June through November. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. During dry periods, however, there are few to no changes in water flows or changes during the winter and spring periods. All potential noticeable changes in flows and stages would diminish rapidly downstream from the RBPP.

Similar to other comprehensive plans, changes in river flow and stages may impact geomorphic conditions, existing riparian vegetation, and wildlife resources of the upper Sacramento River. As mentioned above, the changes in temperature and flows are expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered temperature and flow regime may adversely impact warm-water species in the Sacramento River. This effect is not expected to be significant.

No effects on cultural resources are expected to occur in the upper Sacramento River region.





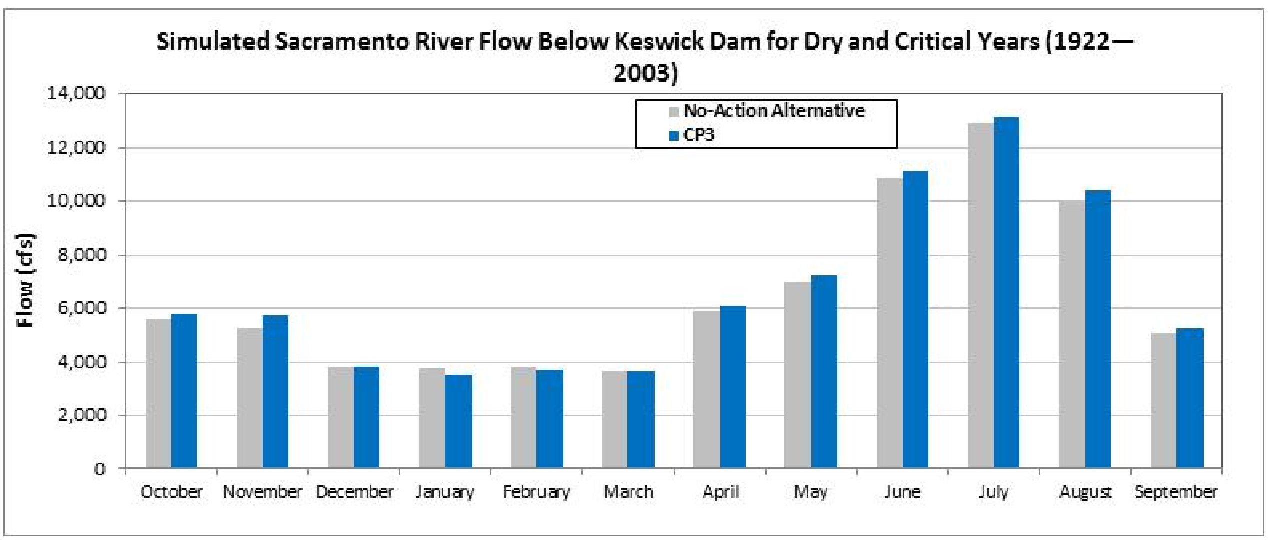


Figure 5-20. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action and CP3

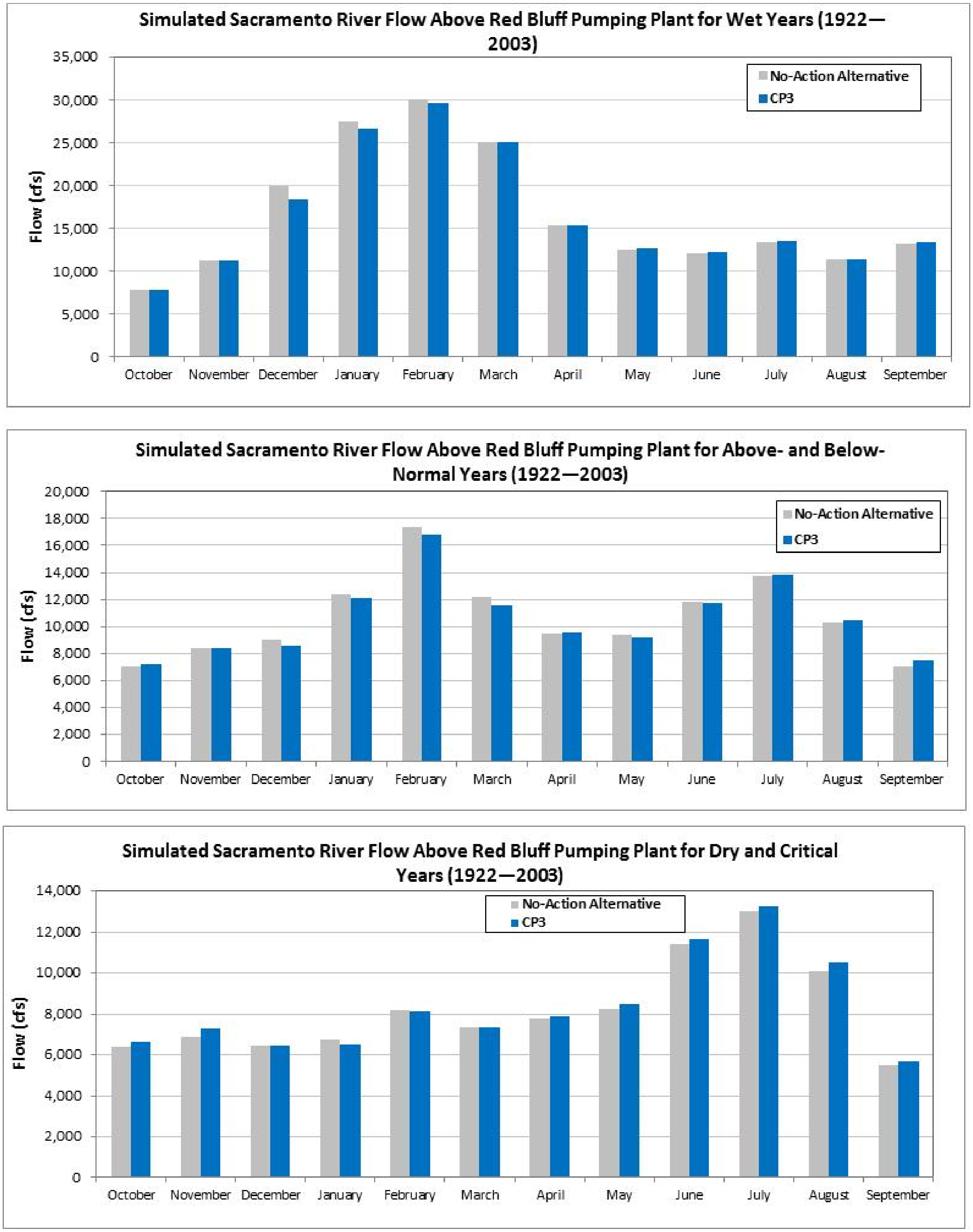


Figure 5-21. Simulated Sacramento River Flow Below Red Bluff Pumping Plant in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action and CP3

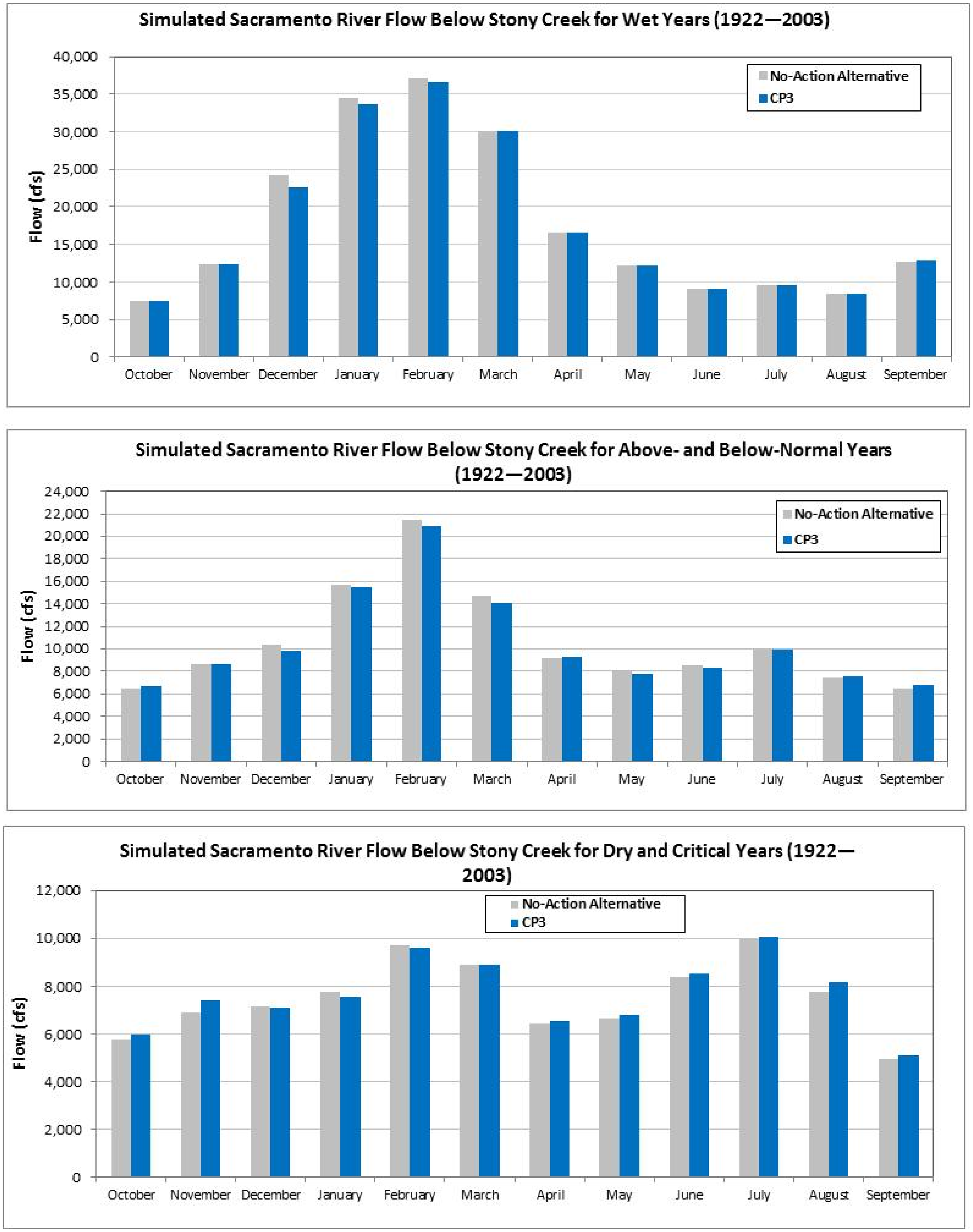


Figure 5-22. Simulated Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action and CP3

CP4 and CP4A – 18.5-Foot Dam Raise, Anadromous Fish Focus with Water Supply Reliability

CP4 and CP4A focus on increasing anadromous fish survival by raising Shasta Dam 18.5 feet, while also increasing water supply reliability. CP4 and CP4A are identical except for Shasta Dam and reservoir operations. CP4 and CP4A have similar reservoir operations in that they each dedicate a portion of the new storage in Shasta Lake for fisheries purposes, however, the portion of this dedicated storage varies. Major features of CP4 and CP4A in the Shasta Lake area are shown in Figure 5-3 and summarized in Table 5-6.

Major Components of CP4 and CP4A

Major components of CP4 and CP4A include the following:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Reserving a portion of the increased storage in Shasta Lake for maintaining cold-water volume or augmenting flows as part of an adaptive management plan for anadromous fish survival (378,000 acre-feet for CP4, 191,000 acre-feet for CP4A).
- Augmenting spawning gravel in the upper Sacramento River.
- Restoring riparian, floodplain, and side channel habitat in the upper Sacramento River.
- Implementing the set of eight common management measures, described above.
- Implementing the common environmental commitments described above.

By raising Shasta Dam 18.5 feet from a crest elevation of 1,077.5 feet to 1,096.0 feet (based on NGVD29), CP4 or CP4A would increase the height of the reservoir full pull by 20.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to the modifications proposed under CP1. This increase in full pool height would add approximately 634,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would be increased from 4.55 MAF to 5.19 MAF.

The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet temperature objectives and habitat requirements for anadromous fish during drought years, while increasing water supply reliability. Of the increased reservoir storage space of CP4, about 378,000 acre-feet would be dedicated to increasing the cold-water supply for anadromous fish purposes. Of the increased storage space of CP4A, about 191,000 acre-feet would be dedicated to increasing the supply of cold water for anadromous fish survival purposes. Figure 5-4 shows the increase in surface area and storage capacity for CP4 and CP4A.

For CP4, operations for the remaining portion of increased storage (approximately 256,000 acre-feet) would be the same as in CP1, with 70,000 acre-feet reserved in dry years and 35,000 acre-feet reserved in critical years to specifically focus on increasing M&I deliveries. For CP4A, operations for the remaining portion of increased storage (approximately 443,000 acre-feet) would be the same as in CP2, with 120,000 acre-feet reserved in dry years and 60,000 acre-feet reserved in critical years to specifically focus on increasing M&I deliveries. The existing TCD would also be extended to achieve efficient use of the expanded cold-water pool for CP4 or CP4A.

As described for the above plans, both CP4 and CP4A would include the potential to revise the operational rules for flood control for Shasta Dam and Reservoir, which could reduce the potential for flood damage and benefit recreation.

CP4 and CP4A also include an adaptive management plan for the cold-water pool, augmenting spawning gravel, and restoring riparian, floodplain, and side channel habitat at one or more sites in the upper Sacramento River.

Adaptive Management of Cold-Water Pool Both CP4 and CP4A may also include development of an adaptive management plan for the storage capacity dedicated to increasing the supply of cold water for anadromous fish survival (378,000 acre-feet for CP4, 191,000 acre-feet for CP4A). The adaptive management plan may include operational changes to the timing and magnitude of releases from Shasta Dam to benefit anadromous fish, as long as there are no conflicts with current operational guidelines or adverse impacts on water supply reliability. These changes may include increasing minimum flows, timing releases from Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional water in storage to meet temperature requirements. Reclamation would manage the cold-water pool each year in cooperation with the SRTTG. Because adaptive management is predicated on using best available science and new information to make decisions, a monitoring program would be implemented as part of the adaptive management plan. SRTTG would conduct monitoring, develop monitoring protocols, and set performance standards to determine the success of adaptive management actions. Adaptive management of the cold-water pool for anadromous fish is discussed further below under “Operations and Maintenance for CP4 and CP4A.”

Augment Spawning Gravel in Upper Sacramento River Gravel suitable for spawning has been identified as a significant influencing factor in the recovery of anadromous fish populations in the Sacramento River (USFWS 2001, NMFS 2009a). Reclamation replenishes spawning gravel in the upper reaches of the Sacramento River, immediately below Keswick Dam and at Salt Creek, as part of the CVPIA. However, the annual gravel budget deficit is estimated to be far greater than what the CVPIA program currently supplies (Hannon 2008). Under CP4 and CP4A, spawning-sized gravel would be injected at multiple locations along the Sacramento River between Keswick Dam and the RBPP.

In December 2008, a workshop was held with Reclamation, USFWS, and CDFW to identify the goals and priorities of the SLWRI gravel augmentation program. Input from the resource agencies during the workshop was used to define the program. Gravel augmentation would occur at one to three locations every year, for a period of 10 years, unless unusual conditions or agency requests precluded placement during a single year. This program, in addition to the ongoing CVPIA gravel augmentation program, would help address the gravel deficit in the upper Sacramento River. However, this reach may continue to be gravel-limited in the future. Therefore, the proposed gravel augmentation program would be reevaluated after the 10-year period to assess the need for continued spawning gravel augmentation, and to identify opportunities for future gravel augmentation actions.

On average, 5,000 to 10,000 tons of gravel would be placed each year, although the specific quantity of gravel placed in a given year may vary from that range. Gravel would be obtained as uncrushed, rounded river rock, free of debris and organic material from local, commercial sources. To maximize the benefit to anadromous fish, gravel would be washed and sorted to meet specific size criteria. To minimize impacts on salmonid spawning activity, gravel placement within the active river channels would occur between August and September each year, consistent with the time frame for the ongoing CVPIA gravel augmentation.

Input from the resource agencies during the December 2008 led to the identification of 15 potential areas for spawning gravel augmentation in the Sacramento River between Keswick Dam and Shea Island. Selection of specific locations was based on potential benefits to anadromous fish and site accessibility. Gravel placement would provide either immediate spawning habitat or long-term recruitment.

Fifteen preliminary locations for spawning gravel augmentation were identified in the Sacramento River between Keswick Dam and Shea Island. Each site would be eligible for gravel placement one or more times during the 10-year program. Selection of these locations was based on potential benefits to anadromous fish and site accessibility. Gravel placement would provide either immediate spawning habitat or long-term recruitment.

Although preliminary sites have been identified, specific gravel augmentation site(s) and volume(s) would be selected each year in the spring or early summer through discussions among Reclamation, USFWS, CDFW, and NMFS. The discussions would include topics such as: avoiding redundancy with planned CVPIA gravel augmentation activities in a given year; identifying hydrology or morphology issues that could affect the potential benefit of placing gravel at any particular site; identifying changes in spawning trends based on ongoing CVPIA monitoring efforts; evaluating potential new sites; and appropriately distributing selected gravel sites along the river reach(es).

Restore Riparian, Floodplain, and Side Channel Habitat Under CP4 and CP4A, riparian, floodplain, and side channel habitat restoration would occur at one or a combination of potential locations along the upper Sacramento River. Restoration measures for six potential sites, referred to collectively as “upper Sacramento River restoration sites”, are described below. The sites under consideration for habitat restoration are shown in Figure 5-23.

Henderson Open Space The City of Redding Henderson Open Space area is located south of Cypress Bridge on the east side of the Sacramento River at River Mile (RM) 295. Riparian and side channel restoration at the Henderson Open Space site could consist of enhancing an existing side channel to activate the frequency and duration of flows for Chinook salmon spawning habitat throughout the side channel. This potential modification would create up to 2,000 more linear feet of spawning habitat near areas of the Sacramento River that are actively used by anadromous fish for spawning.

Tobiasson Island Tobiasson Island is located downstream from South Bonnyview Bridge in the center of the Sacramento River at RM 292. Riparian, floodplain, and side channel habitat enhancement at this site would involve creating a side channel through the island to be activated at Sacramento River flows for Chinook salmon spawning. Riparian vegetation would be established along the course of the new side channel, adding approximately 1,350 linear feet of spawning and floodplain habitat to this section of the Sacramento River.

Shea Island Complex The Shea Island Complex is located on the west side of the Sacramento River upstream from the river’s confluence with Clear Creek at RM 291. Restoration at the Shea Island Complex to improve side channel, riparian, and floodplain habitat would involve enhancing a major side channel through the site to keep the side channel hydraulically connected with the main stem of the Sacramento River at a broader range of flows. Adding channel complexity and enhancing riparian vegetation throughout the length of the side channel would improve Chinook salmon habitat along an additional 1,930 feet of the Sacramento River.

Kapusta Island Kapusta Island is located adjacent to the Kapusta Open Space area upstream from the I-5 crossing of the Sacramento River at RM 288. Restoration of riparian, side channel and floodplain habitat at Kapusta Island would involve enhancing an existing side channel by allowing it to carry water at a broader range of flows specifically to increase spawning habitat for winter-run and spring-run Chinook salmon. Allowing flow through the island, and increasing floodplain habitat would increase potential spawning habitat in this area of the river by about 1,590 linear feet.

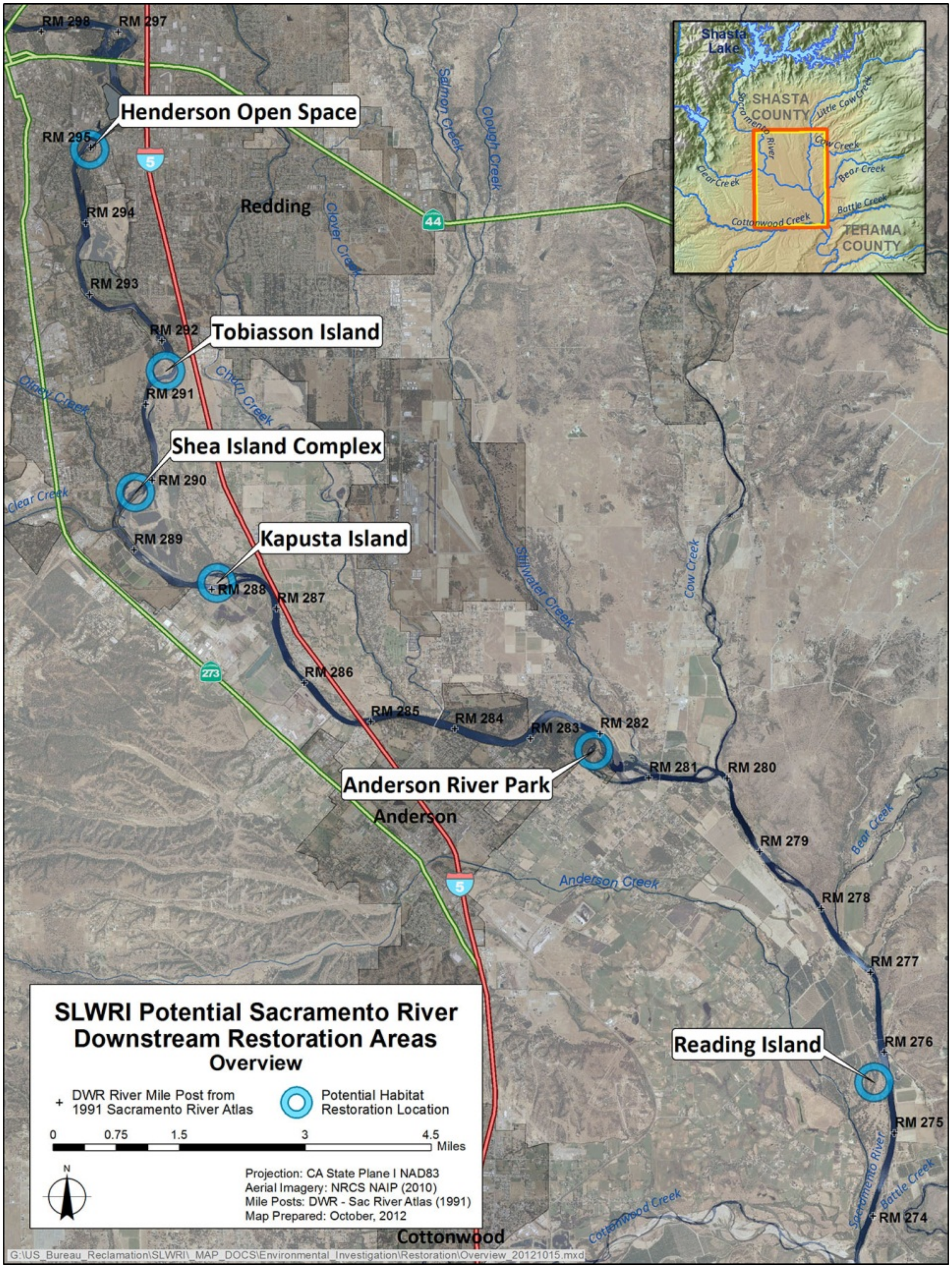


Figure 5-23. Potential Sacramento River Habitat Restoration Areas

Anderson River Park Anderson River Park is an open space area on the south bank of the Sacramento River downstream from Churn Creek, and upstream from the Deschutes Road crossing at RM 283. Restoration at this site would involve hydraulically reconnecting a remnant Sacramento River side channel with the Sacramento River. Regularly flowing water throughout the length of this side channel would increase anadromous fish rearing habitat along 4,750 feet of side channel in this section of the river.

Reading Island Reading Island lies along the Sacramento River just north of Cottonwood Creek at RM 274. The channel for Anderson Creek, a remnant Sacramento River side channel, defines the western edge of Reading Island. Construction of a levee on Anderson Creek has blocked the channel's connectivity with the Sacramento River and has created Anderson Slough, an area of still water. Riparian, floodplain, and side channel restoration on Reading Island would involve restoring flows in Anderson Creek and through Anderson Slough. These activities, alongside removal of invasive aquatic vegetation in the channel and reestablishment of riparian vegetation would aid in restoring rearing habitat for winter-run Chinook, and spawning habitat for steelhead along 4,225 feet of channel in this area of the river.

Potential Benefits of CP4 and CP4A

Major potential benefits of CP4 and CP4A, related to the planning objectives and broad public services, are described below.

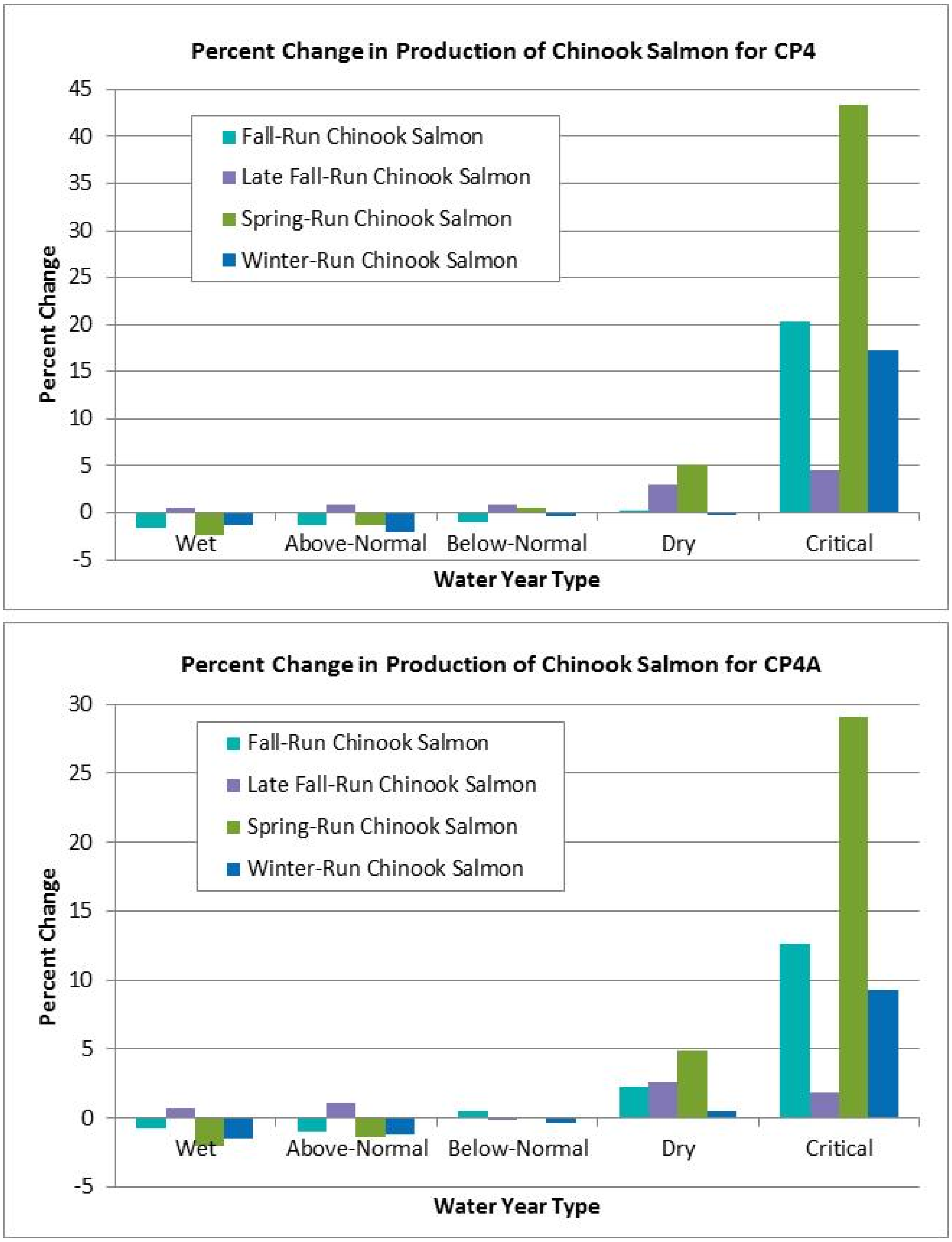
Increase Anadromous Fish Survival Water temperature is one of the most important factors affecting anadromous fish survival in the Sacramento River. CP4 or CP4A would increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures for fish in the upper Sacramento River, primarily in dry and critical water years. CP4 would significantly increase the ability of Shasta Dam to make cold-water releases and regulate water temperature in the upper Sacramento River. CP4 would benefit anadromous fish by improving temperature conditions in the upper Sacramento River, primarily in dry and critical water years. This would be accomplished by raising Shasta Dam 18.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBPP. Hence, the most significant water temperature benefits to anadromous fish would occur upstream from the RBPP.

It is estimated that improved temperature and flow conditions under CP4 could result in an average annual increase in Chinook salmon population of nearly 812,600 out-migrating juvenile fish. It is estimated that improved water temperature and flow conditions under CP4A could result in an average annual increase in Chinook salmon population of nearly 710,000 out-migrating juvenile fish.

Under CP4 and CP4A, an increase in the cold-water pool would allow Reclamation to operate Shasta Reservoir to provide not only a more reliable source of water during dry and critical water years, but also to provide more cool water for release into the Sacramento River to improve conditions for anadromous fish. Of the increased storage space for CP4, about 378,000 acre-feet (60 percent) would be dedicated to increasing the cold-water supply for anadromous fish survival purposes. Of the increased storage space for CP4A, about 191,000 acre-feet (30 percent) would be dedicated to increasing the cold-water supply for anadromous fish survival purposes. Reclamation would manage the cold-water pool each year based on recommendations from the SRTTG. To assess the effects of operations on Chinook salmon in the upper Sacramento River, the computer model SALMOD was upgraded to evaluate changes in Chinook salmon population between Keswick Dam and the RBPP. In response to changes in Shasta Reservoir operations under CP4 and CP4A during dry and critical water years – the years targeted for improving water reliability for both users and fish – SALMOD modeling showed increases in production of Chinook salmon populations, especially winter-run and spring-run Chinook (Figure 5-24).

In addition, CP4 and CP4A include a gravel augmentation program. Gravel augmentation would occur on average at one or more locations in the Sacramento River between Keswick Dam and the RBPP for a period of 10 years. On average, 5,000 to 10,000 tons of gravel would be placed each year, although the specific quantity of gravel placed in a given year may vary from that range. Spawning gravel augmentation is expected to positively influence anadromous fish populations in the Sacramento River.

Potential benefits to anadromous fish survival through conserving, restoring, and enhancing ecosystem resources are described below.



Note: Simulated using SALMOD; Water Year Types Based on the Sacramento Valley Water Year Hydrologic Classification

Figure 5-24. Percent Change in Production of Chinook Salmon for CP4 and CP4A

Increase Water Supply Reliability CP4 or CP4A would increase water supply reliability by increasing water supplies for CVP and SWP irrigation and M&I deliveries. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. CP4 would help reduce estimated future water shortages by increasing the reliability of dry and critical year water supplies for agricultural and M&I deliveries by at least 47,300 acre-feet per year and average annual deliveries by about 31,000 acre-feet per year. CP4A would help reduce estimated future water shortages by increasing the reliability of dry and critical year water supplies for agricultural and M&I deliveries by at least 77,800 acre-feet per year and average annual deliveries by about 51,300 acre-feet per year. As shown in Table 5-7, the majority of increased dry and critical year water supplies, 42,700 acre-feet for CP4 and 67,100 acre-feet for CP4A, would be for south-of-Delta agricultural and M&I deliveries. In addition, water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban uses resulting from water shortages. Under CP4 and CP4A, approximately $1.6 million and $2.6 million, respectively, would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 127 GWh per year for CP4 and 125 GWh for CP4A. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities. Other power benefits for both CP4 and CP4A include additional capacity (i.e., the rate at which power can be generated) and ancillary services, which provide the ability to manage the electric grid in a reliable manner.

Conserve, Restore, and Enhance Ecosystem Resources In the upper Sacramento River, the addition of spawning gravel and the restoration of riparian, floodplain, and side channel habitat are expected to improve the complexity of aquatic habitat and its suitability for anadromous salmonid spawning and rearing habitat. Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including several threatened or endangered species. Riparian areas also provide shade and woody debris that increase the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. Restoration would support the goals of the Sacramento River Conservation Area Forum and other programs associated with riparian restoration along the Sacramento River. Side channels can support important habitat for anadromous salmonids, including rearing and spawning habitat. Side channel habitats also provide refuge from predators and productive foraging habitat for juvenile anadromous salmonids. In addition, improved fisheries conditions as a result of cold-water carryover storage in CP4 or CP4A, as described above, and increased flexibility to meet flow and temperature requirements, could also enhance overall ecosystem resources in the Sacramento River.

Maintain and Increase Recreation Opportunities CP4 and CP4A include features to, at a minimum, maintain the existing recreation capacity at Shasta Lake. Potential recreation benefits would be similar to CP3. Although neither CP4 nor CP4A include specific features to further increase recreation capacity, benefits to the water-oriented recreation experience at Shasta Lake would likely occur because of the increase in average lake surface area, reduced drawdown during the recreation season, and modernization of recreation facilities. For CP4 and CP4A, the maximum surface area of the lake would increase by about 2,600 acres (9 percent), from 29,700 acres to about 32,300 acres. For CP4, the average surface area of the lake during the recreation season from May through September would increase by about 2,600 acres (11 percent), from 23,900 acres to 26,500 acres. For CP4A, average surface area of the lake during the recreation season from May through September would increase by about 2,300 acres (10 percent), from 23,900 acres to 26,200 acres. There is also limited potential to provide additional benefits to recreation by allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other Planning Objectives CP4 and CP4A could also provide benefits related to flood damage reduction and water quality, similar to CP1.

Additional Broad Public Benefits Additional broad public benefits of CP4 and CP4A obtained through pursuing project objectives are summarized in Table 5-8. Broad public benefits for CP4 are similar to those for CP3.

Construction for CP4 and CP4A

Construction activities associated with physical features under CP4 and CP4A would include land-based construction activities associated with the following:

- Clearing vegetation from portions of the inundated reservoir area
- Constructing the dam raise, appurtenant structures, reservoir area dikes, and railroad embankments
- Relocating roadways, bridges, recreation facilities, utilities, and miscellaneous minor infrastructure
- Augmenting spawning gravel in the upper Sacramento River
- Restoring riparian, floodplain, and side channel habitat

Construction activities for CP4 are described in detail in the Engineering Summary Appendix.

Operations and Maintenance for CP4 and CP4A Operations differ between CP4 and CP4A, as described below. The anticipated maintenance for CP4 and CP4A are identical to one another.

Operations for CP4

Operations under CP4 are governed by the same regulatory constraints as described for CP1. Under CP4, the additional storage would be retained to increase water supply reliability and to expand the cold-water pool in Shasta Reservoir for fisheries benefits. Of the 634,000 acre-feet of additional storage, 378,000 acre-feet of water (60 percent) would be dedicated to increasing the cold-water supply for anadromous fish survival purposes. This would be in addition to any storage targets set by regulations described in Chapter 6 of the EIS, “Hydrology, Hydraulics, and Water Management.” Similar to CP1, Shasta Dam operational guidelines would continue unchanged under CP4, except during dry and critical years, when 70,000 acre-feet and 35,000 acre-feet, respectively, of the increased storage capacity in Shasta Reservoir would be operated primarily to provide increased M&I deliveries. Operations targeting increased M&I deliveries were based on existing and anticipated future demands, operational priorities, and facilities of the SWP.

As modeled for CP4, the 378,000 acre-feet of additional water would be the first increment of the reservoir filled after the reservoir was enlarged. This amount of water would be available as additional water for the cold-water pool each year regardless of water year type, unless Reclamation elected to use the additional water to augment flows protecting anadromous fish in the Sacramento River, as part of a proposed adaptive management plan, as explained below. An additional 256,000 acre-feet of the increased storage space would be used primarily to improve water supply reliability; operations of Shasta Dam related to the 256,000 acre-feet of storage would be similar to operations under CP1.

As stated above, of the total 634,000 acre-feet of additional storage, 378,000 acre-feet of water would be used to increase the cold-water pool for fisheries. Reclamation is currently working with NMFS, USFWS, and CDFW through the SRTTG, a multiagency group established to adaptively manage flows and water temperatures in the Sacramento River to improve and stabilize Chinook salmon populations in the upper Sacramento River. The additional 378,000 acre-feet of cold-water pool would be managed by Reclamation in coordination with the SRTTG.

Current analysis indicates that the most beneficial use of the additional 378,000 acre-feet of storage for fisheries protection is as an expanded cold-water pool; however, Reclamation has agreed to adaptively manage the 378,000 acre-feet of water, as appropriate, to increase benefits to anadromous fish as part of CP4. Adaptive management is an approach allowing decision makers to take advantage of a variety of strategies and techniques that are adjusted, refined, and/or modified based on an improved understanding of system dynamics. Adaptive management, if applied appropriately, allows for flexible operations based on best available science and new information as it becomes available.

The adaptive management plan may include operational changes to the timing and magnitude of releases primarily to improve the quality and quantity of aquatic habitat. These changes may include increasing minimum flows, timing releases from Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional 378,000 acre-feet of water in storage to meet temperature requirements. Reclamation would work cooperatively with the SRTTG to determine the best use of the cold-water pool each year under an adaptive management plan. Reclamation would manage the cold-water pool and operate Shasta Dam each year based on recommendations from the SRTTG. Because adaptive management is predicated on using best available science and new information to make decisions, a monitoring program would be implemented as part of the adaptive management plan. SRTTG members would conduct monitoring, develop monitoring protocols, and set performance standards to determine the success of adaptive management actions.

Under the currently proposed operations, the 378,000 acre-feet of additional storage would be the first increment of water in the reservoir to fill after dam enlargement. This water would be available each year independent of water year type if used exclusively to enlarge the cold-water pool. If the 378,000 acre-feet of stored water is used to augment flows based on recommendations from the SRTTG, this water would not be guaranteed to be available for use the following year because of uncertainty in hydrologic conditions. Once water was released to augment flows as part of the adaptive management plan, the 378,000 acre-feet of additional storage space would be refilled after the 256,000 acre-feet of additional storage space was filled for the primary purpose of increasing water supply reliability. Each year that the 378,000 acre-feet of additional water was held in storage as part of an increase in the cold-water pool, the allocated amount would be available as long as the cold-water pool continued to provide benefits to fisheries.

SALMOD modeling and related analysis indicate that in most cases, providing an increased cold-water pool benefits Chinook salmon populations in the Upper Sacramento River more than increasing flows. Therefore, the impacts and benefits of increasing flows under CP4 are not presented in this EIS. Per recommendations in Title 43 of the Code of Federal Regulations, Part 46, Section 46.145, substantive increases in flows associated with the adaptive management plan would be evaluated in subsequent NEPA analysis.

Operation of pumping facilities downstream from Shasta Dam would vary slightly from current operations and would result in higher costs. In addition, Reclamation would provide in-kind power to offset reduced generation at Pit 7 Dam and related facilities.

Operations for CP4A As modeled for CP4A, the 191,000 acre-feet of additional water would be the first increment of the reservoir filled after the reservoir was enlarged. This amount of water would be available as additional water for the cold-water pool each year regardless of water year type, unless Reclamation elected to use the additional water to augment flows protecting anadromous fish in the Sacramento River, as part of a proposed adaptive management plan, as explained below. An additional 443,000 acre-feet of the increased storage space would be used primarily to improve water supply reliability; operations of Shasta Dam related to the 443,000 acre-feet of storage would be similar to operations under CP2.

As stated above, of the total 634,000 acre-feet of additional storage, 191,000 acre-feet of water would be used to increase the cold-water pool for fisheries. Reclamation is currently working with NMFS, USFWS, and CDFW through the SRTTG, a multiagency group established to adaptively manage flows and water temperatures in the Sacramento River to improve and stabilize Chinook salmon populations in the upper Sacramento River. The additional 191,000 acre-feet of cold-water pool would be managed by Reclamation in coordination with the SRTTG.

Current analysis indicates that the most beneficial use of the additional 191,000 acre-feet of storage for fisheries protection is as an expanded cold-water pool; however, Reclamation has agreed to adaptively manage the 191,000 acre-feet of water, as appropriate, to increase benefits to anadromous fish as part of CP4A. Adaptive management is an approach allowing decision makers to take advantage of a variety of strategies and techniques that are adjusted, refined, and/or modified based on an improved understanding of system dynamics. Adaptive management, if applied appropriately, allows for flexible operations based on best available science and new information as it becomes available.

The adaptive management plan may include operational changes to the timing and magnitude of releases primarily to improve the quality and quantity of aquatic habitat. These changes may include increasing minimum flows, timing releases from Shasta Dam to mimic more natural seasonal flows, meeting flow targets for side channels, or retaining the additional 191,000 acre-feet of water in storage to meet temperature requirements. Reclamation would work cooperatively with the SRTTG to determine the best use of the cold-water pool each year under an adaptive management plan. Reclamation would manage the cold-water pool and operate Shasta Dam each year based on recommendations from the SRTTG. Because adaptive management is predicated on using best available science and new information to make decisions, a monitoring program would be implemented as part of the adaptive management plan. SRTTG members would conduct monitoring, develop monitoring protocols, and set performance standards to determine the success of adaptive management actions.

Under the currently proposed operations, the 191,000 acre-feet of additional storage would be the first increment of water in the reservoir to fill after dam enlargement. This water would be available each year independent of water year type if used exclusively to enlarge the cold-water pool. If the 191,000 acre-feet of stored water is used to augment flows based on recommendations from the SRTTG, this water would not be guaranteed to be available for use the following year because of uncertainty in hydrologic conditions. Once water was released to augment flows as part of the adaptive management plan, the 191,000 acre-feet of additional storage space would be refilled after the 443,000 acre-feet of additional storage space was filled for the primary purpose of increasing water supply reliability. Each year that the 191,000 acre-feet of additional water was held in storage as part of an increase in the cold-water pool, the allocated amount would be available as long as the cold-water pool continued to provide benefits to fisheries.

SALMOD modeling and related analysis indicate that in most cases, providing an increased cold-water pool benefits Chinook salmon populations in the Upper Sacramento River more than increasing flows. Therefore, the impacts and benefits of increasing flows under CP4A are not presented in this EIS. Per recommendations in Title 43 of the CFR, Part 46, Section 46.145, substantive increases in flows associated with the adaptive management plan would be evaluated in subsequent NEPA analysis.

Operation of pumping facilities downstream from Shasta Dam would vary slightly from current operations and would result in higher costs. In addition, Reclamation would provide in-kind power to offset reduced generation at Pit 7 Dam and related facilities.

Maintenance for CP4 and CP4A Maintenance of facilities related to the proposed dam and reservoir enlargement would be similar to maintenance activities currently conducted at Shasta Dam and Reservoir.

Potential Primary Effects of CP4 and CP4A

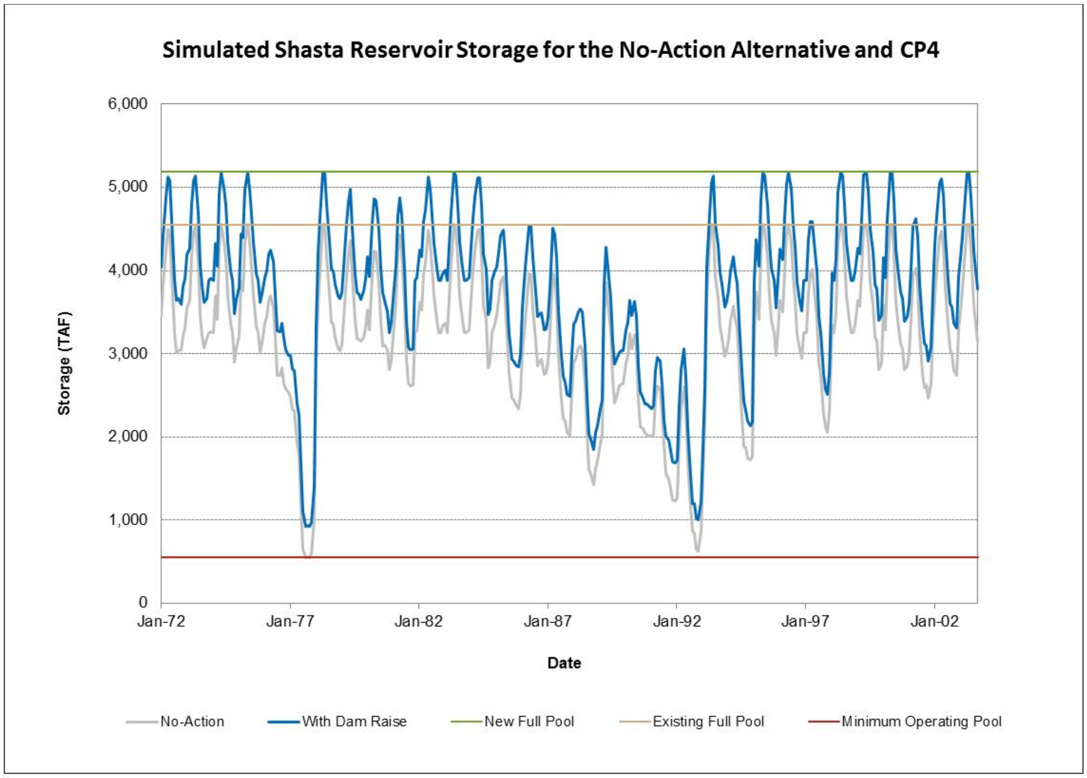
Following is a summary of potential environmental consequences of CP4 and CP4A. Potential environmental effects are generally comparable between comprehensive plans; some adverse effects would be exacerbated by larger dam raises and the associated scale of those effects, such as expanded construction areas and increased area of inundation around Shasta Lake. Anticipated inundation, construction, cultural, and relocation impacts associated with CP4 and CP4A are similar to CP3, as summarized above. Proposed mitigation measures to address potential adverse impacts of CP4 and CP4A are summarized in Table 5-9. A detailed discussion of potential effects and proposed mitigation measures associated with raising Shasta Dam by 18.5 feet are included in Chapters 4 through 25 of the EIS.

Shasta Lake Area As with the other comprehensive plans, the primary long-term effects of CP4 and CP4A would be due to the increased water surface elevations and inundation area. Anticipated effects of increased water surface elevations under CP4 and CP4A are similar to CP3. As with the above plan, raising the full pool of the lake would cause direct effects due to higher water levels, and/or indirect impacts related to facility access modifications and relocations.

CP4 and CP4A include modifying two bridges and replacing six other bridges, inundating a number of small segments of existing paved and nonpaved roads, and relocating a number of potable water facilities, wastewater facilities, gas and petroleum facilities, and power distribution and telecommunications facilities. A number of recreation facilities would also be impacted, including campgrounds, marinas, resorts, boat ramps, day use areas, and trails. Approximately 30 segments of roadway would be relocated, including portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road. Embankments would be constructed to protect I-5 at Lakeshore and the UPRR at Bridge Bay. Any potential real estate acquisitions or necessary relocations of displaced parties would be accomplished under Public Law 91-646.

With CP4 and CP4A, Shasta Reservoir would fill to the new full pool storage capacity of 5.19 MAF at a frequency similar to without-project conditions. On the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent of its current capacity in about 81 percent of the years over the 82-year period of analysis of the CalSim-II model. Included in Figure 5-5 is an exceedence probability relationship of maximum annual storage in Shasta Lake for this and other dam raises.

Under CP4, Shasta Reservoir would also fill to 80 percent of the new capacity in about 82 percent of the years. Under CP4A, Shasta Reservoir would fill to 80 percent of the new capacity in about 77 percent of the years. Accordingly, the annual operations in the reservoir under CP4 and CP4A would generally mirror existing operations, except the water surface in the lake would be about 18.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to approximately 378,000 acre-feet above without-project minimum levels under CP4 and 191,000 acre-feet above without-project minimum levels under CP4A. This is because of the dedicated storage capacity for increasing the cold-water pool for anadromous fish purposes. Figure 5-25 shows the changes from without-project conditions for CP4 and CP4A for a representative period of 1972 through 2003.



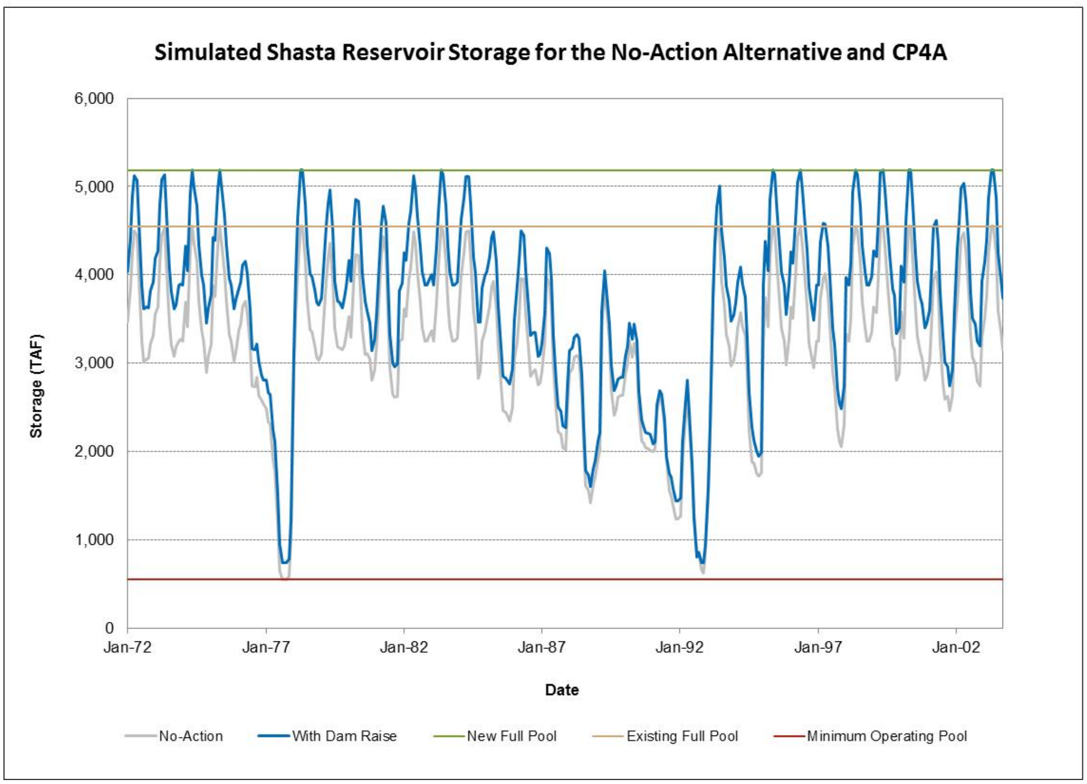


Figure 5-25. Simulated Shasta Reservoir Storage from 1972 to 2003 for CP4 and CP4A Compared to the No-Action Alternative

The increased area of inundation for CP4 and CP4A is about 2,600 acres. As with the previous plans, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

As shown in Figure 5-9, raising Shasta Dam 18.5 feet would result in inundating an additional 3,550 linear feet (about 27 acres) of the lower McCloud River. This represents about 3 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

As shown in Figure 5-25, since a portion of the increased storage capacity would be dedicated to increasing the cold-water pool, water levels in the lake under CP4 and CP4A would generally be higher than under without-project conditions. It is anticipated that recreation use would generally improve under CP4 and CP4A because of a larger lake surface area, reduced drawdown during the recreation season, and modernization of recreation facilities. Although water levels would generally be higher than under existing conditions and drawdown during the recreation season would generally be reduced, during some dry years, the total drawdown zone could increase under CP4 and CP4A. Figure 5-18 illustrates that the minimum clearance at the new full pool would be about 14 feet between Piers 6 and 7. This could impact boating on the lake, as some houseboats exceed 16 feet in height. Since houseboating is a major recreational experience on Shasta Lake, especially around Memorial Day, restrictions on large boat traffic under the Pit River Bridge during maximum pool levels could adversely impact lake area boat rentals, marinas, and other recreation-dependent businesses.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP4 and CP4A include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP4 and CP4A, approximately 391 and 529 historic sites are within the inundation zone and fluctuation, respectively. Effects to traditional cultural properties and sacred sites under CP4 would be similar to CP1.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related impacts are also anticipated in the primary study area.

Upper Sacramento River Potential effects on flow and stages of the upper Sacramento River from CP4 are identical to CP1. Figures 5-11, 5-12, and 5-13 show simulated Sacramento River flows below Keswick Dam, RBPP, and

Stony Creek, respectively, under wet, average, and dry year conditions for the No-Action Alternative compared to CP1 and CP4.

Potential effects on flow and stages of the upper Sacramento River from CP4A are identical to CP2. Figures 5-15, 5-16, and 5-17 show simulated Sacramento River flows below Keswick Dam, RBPP, and Stony Creek, respectively, under wet, average, and dry year conditions for the No-Action Alternative compared to CP2 and CP4A.Some potential exists for impacting existing habitat at upper Sacramento River restoration sites, but these impacts would likely result from converting present land use back to a more typical riverine environment.

CP5 – 18.5-Foot Dam Raise – Combination Plan

CP5 primarily focuses on increasing water supply reliability, anadromous fish survival, Shasta Lake area environmental resources, and increased recreation opportunities. Major features of CP5 are shown in Figure 5-3 and summarized in Table 5-6.

Major Components of CP5

This plan includes the following major components:

- Raising Shasta Dam and appurtenant facilities by 18.5 feet.
- Constructing additional resident fish habitat in Shasta Lake and along the lower reaches of its tributaries (Sacramento River, McCloud River, and Squaw Creek).
- Constructing shoreline fish habitat around Shasta Lake.
- Augmenting spawning gravel in the upper Sacramento River.
- Restoring riparian, floodplain, and side channel habitat in the upper Sacramento River.
- Increasing recreation opportunities at various locations at Shasta Lake.
- Implementing the set of eight common management measures described above.
- Implementing the common environmental commitments previously described.

By raising Shasta Dam 18.5 feet from a crest elevation of 1,077.5 feet to 1,096.0 feet (based on NGVD29), CP5 would increase the height of the reservoir full pull by 20.5 feet. The additional 2-foot increase in the height of the full pool above the dam raise height would result from spillway modifications similar to the modifications proposed under CP1. This increase in full pool height would add approximately 634,000 acre-feet of storage to the reservoir's capacity. Accordingly, storage in the overall full pool would be increased from 4.55 MAF to 5.19 MAF. Figure 5-4 shows the increase in surface area and storage capacity for CP5.

Under CP5, the additional storage in Shasta Reservoir would be used to increase water supply reliability and to expand the cold-water pool for downstream anadromous fisheries. The existing TCD would be extended to achieve efficient use of the expanded cold-water pool. Operations for water supply, hydropower, and environmental and other regulatory requirements would be similar to existing operations, except during dry and critical years when a portion of the increased storage in Shasta Reservoir would be reserved to specifically focus on increasing M&I deliveries. In dry years, 150,000 acre-feet of the 634,000 acre-feet increased storage capacity in Shasta Reservoir would be reserved for increasing M&I deliveries. In critical years, 75,000 acre-feet of the increased storage capacity would be reserved for increasing M&I deliveries.

As described for the above plans, this plan also would include the potential to revise the flood control operational rules for Shasta Dam and Reservoir, which could reduce the potential for flood damage reduction and benefit recreation.

CP5 also involves (1) restoring resident fish habitat in Shasta Lake, (2) restoring fisheries and riparian habitat at several locations along the lower reaches of the tributaries to Shasta Lake, (3) augmenting spawning gravel in the upper Sacramento River, (4) restoring riparian, floodplain, and side channel habitat in the upper Sacramento River, and (5) increasing recreation opportunities at Shasta Lake.

Construct Reservoir Shoreline Enhancement The ecosystem enhancement goal for the shoreline environment of Shasta Lake is to improve the warm-water fish habitat associated with the transition between the reservoir's aquatic and terrestrial habitats. Shoreline enhancement entails the range of enhancement opportunities along the Shasta Lake shoreline below the full pool elevation of 1,090 feet (based on the North American Vertical Datum of 1988 (NAVD88))[3] that would occur with an 18.5-foot dam raise. This area is typically between 0.1 mile and 1.5 miles upslope from the current full pool elevation of 1,070 feet (based on NAVD88). The shoreline is defined as the area encompassing nearshore aquatic habitat within the reservoir itself, and vegetation and other habitat components adjacent to the reservoir.

Two categories of potential nearshore warm-water fish habitat enhancement activities are (1) structural enhancements, which entail placing artificial structures in Shasta Lake's littoral zone, and (2) vegetative enhancements, which entail planting and seeding to provide submerged and partly submerged

[3] Shasta Lake water surface elevations are based on NAVD88. All current feasibility-level designs and figures for reservoir area infrastructure modifications and relocations to accommodate increased water levels are based on a 2001 aerial survey of the reservoir which was completed using NAVD88.

vegetative cover when the reservoir is at full pool capacity during the winter/spring months.

Construction activities common to all action alternatives include stockpiling manzanita for fish habitat. CP5 would include clearing additional manzanita from above the new full pool inundation zone to create further structural enhancements for fish habitat in Shasta Lake's littoral zone.

Vegetative enhancements associated with CP5 include planting willows (Salix) to enhance nearshore fish habitat, and single treatment aerial and hand seeding of annual native grasses to treat shoreline areas at Shasta Lake. Aerial and hand seeding of annual native grasses provides only short-term cover but is cost-effective across large areas and can be implemented quickly and efficiently. The annual native grasses provide cover for young fish and also nutrients for plankton as the grasses decompose. The plankton, in turn, are a valuable food source for juvenile fish.

Construct Reservoir Tributary Aquatic Habitat Enhancement The primary goal for the enhancement of aquatic habitat in the watershed is to enhance the connectivity for native fish species and other aquatic organisms between Shasta Lake and its tributaries. Two categories of potential aquatic habitat enhancement in tributaries are (1) fish passage enhancements, which entail identifying and correcting barriers to fish passage, particularly at culverts and other human-made barriers, and (2) aquatic habitat enhancements, which entail identifying and implementing feasible habitat improvements intended to conserve or restore degraded aquatic and riparian habitat in tributaries to Shasta Lake.

Fish passage enhancements associated with CP5 includes opportunities to restore and/or enhance five perennial stream crossings. Barriers to fish passage in the watersheds above Shasta Lake are associated primarily with culverts or other types of stream crossings.

Aquatic habitat enhancements associated with CP5 involve enhancing aquatic connectivity and reducing sediment related to roads constructed across intermittent streams. The preliminary site survey identified opportunities to enhance 14 intermittent stream crossings. Based on the information obtained in the survey, these crossings provide opportunities for meeting the objectives of enhancing aquatic connectivity and/or reducing the potential for road-related sediment. Two sites have been identified in the Salt Creek watershed, two sites have been identified in the Sugarloaf Creek watershed, and ten sites have been identified in the McCloud River Arm watershed.

Augment Spawning Gravel in Upper Sacramento River As part of CP5, spawning-sized gravel would be placed at multiple locations along the Sacramento River between Keswick Dam and the RBPP. Gravel augmentation under CP5 would be identical to the gravel augmentation component of CP4.

Restore Riparian, Floodplain and Side Channel Habitat As described in CP4, riparian, floodplain, and side channel habitat restoration would occur at suitable locations along the Sacramento River. This measure is identical to that proposed under CP4 and CP4A.

Recreation Enhancements A total of 18 miles of new hiking trails and 6 trailheads would be constructed to enhance recreation under CP5.

Potential Benefits of CP5

Major potential benefits of CP5, related to the planning objectives and broad public services, are described below.

Increase Anadromous Fish Survival Water temperature is one of the most important factors affecting anadromous fish survival in the Sacramento River. CP5 would increase the ability of Shasta Dam to make cold-water releases and regulate water temperature in the upper Sacramento River, primarily in dry and critical water years. This would be accomplished by raising Shasta Dam 18.5 feet, thus increasing the depth of the cold-water pool in Shasta Reservoir and resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperature and density change). Cold water released from Shasta Dam significantly influences water temperature conditions in the Sacramento River between Keswick Dam and the RBPP. Hence, the most significant water temperature benefits to anadromous fish would occur upstream from the RBPP. It is estimated that improved water temperature and flow conditions under CP5 could result in an annual average increase in the Chinook salmon population of about 377,800 outmigrating juvenile Chinook salmon.

Increase Water Supply Reliability CP5 would increase water supply reliability by increasing water supplies for CVP and SWP irrigation and M&I deliveries. This action would contribute to replacement of supplies redirected to other purposes in the CVPIA. CP5 would help reduce estimated future water shortages by increasing the reliability of dry and critical year water supplies for agricultural and M&I deliveries by at least 113,500 acre-feet per year and average annual deliveries by about 75,900 acre-feet per year. As shown in Table 5-7, the majority of increased dry and critical year water supplies, 88,300 acre-feet, would be for south-of-Delta agricultural and M&I deliveries. In addition, increased water use efficiency could help reduce current and future water shortages by allowing a more effective use of existing supplies. As population and resulting water demands continue to grow and available supplies continue to remain relatively static, more effective use of these supplies could reduce potential critical impacts to agricultural and urban areas resulting from water shortages. Under CP5, approximately $3.8 million would be allocated over an initial 10-year period to fund agricultural and M&I water conservation programs, focused on agencies benefiting from increased reliability of project water supplies.

Develop Additional Hydropower Generation Higher water surface elevations in the reservoir would result in a net increase in power generation of about 112 GWh per year. This generation value is the expected increased generation from Shasta Dam and other CVP/SWP facilities. Other power benefits include additional capacity (i.e., the rate at which power can be generated) and ancillary services, which provide the ability to manage the electric grid in a reliable manner.

Conserve, Restore, and Enhance Ecosystem Resources CP5 would provide for habitat improvements both in the reservoir area and downstream from Shasta Dam on the upper Sacramento River.

Along the Shasta Lake shoreline, shallow warm-water fish habitat would be improved by using manzanita cleared from above the inundation zone to create structural enhancements, planting willows (*Salix*) to enhance nearshore fish habitat, and seeding of native grasses to treat shoreline areas. Once established, the willows and native grasses would provide submerged and partly submerged vegetative cover when the reservoir is at full pool capacity during the winter/spring months. These improvements would help provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. Placing manzanita brush structures near the shoreline would enhance the diversity of structural habitat available for the warm-water fish species that occupy Shasta Lake. Establishing vegetation also could benefit terrestrial species that inhabit the shoreline of Shasta Lake.

The lower reaches of perennial tributaries to Shasta Lake would be the focus for aquatic restoration because they provide year-round fish habitat. Native fish species require connectivity to the full range of habitats offered by Shasta Lake and its tributaries. Improved fish passage addresses the requirement to provide access and/or modify barriers necessary to improve ecological conditions that support these native fish assemblages. Aquatic habitat improvements include enhancing aquatic connectivity and reducing sediment related to roads constructed across intermittent streams.

In the upper Sacramento River, the addition of spawning gravel and the restoration of riparian, floodplain, and side channel habitat are expected to improve the complexity of aquatic habitat and its suitability for spawning and rearing. Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that increase the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat. Restoration would support the goals of the Sacramento River Conservation Area Forum and other programs associated with riparian restoration along the Sacramento River. Side channels can support important habitat for anadromous salmonids, including rearing and spawning habitat. Side channel habitats also provide refuge from predators and productive foraging habitat for juvenile anadromous salmonids.

Maintain and Increase Recreation Opportunities CP5 includes features to, at a minimum, maintain the existing recreation capacity at Shasta Lake. In addition, this alternative involves construction of 18 miles of new trails and 6 trailheads to enhance recreation opportunities at Shasta Lake. As with the other alternatives, benefits to the water-oriented recreation experience at Shasta Lake would likely occur because of the increase in average lake surface area, reduced drawdown during the recreation season, and modernization of recreation facilities. The maximum surface area of the lake would increase by about 2,600 acres (9 percent), from 29,700 acres to about 32,300 acres. The average surface area of the lake during the recreation season from May through September would increase by about 1,900 acres (8 percent), from 23,900 acres to 25,800 acres. There is also limited potential for reservoir reoperation to provide additional benefits to recreation by allowing more reliable filling of the reservoir during the spring.

Benefits Related to Other Planning Objectives CP5 could also provide benefits related to flood damage reduction and water quality, similar to CP3.

Additional Broad Public Benefits Additional broad public benefits of CP5 obtained through pursuing project objectives are summarized in Table 5-8. Broad public benefits for CP5 are similar to CP3.

Construction for CP5

Construction activities associated with physical features under CP5 would include land-based construction activities associated with the following:

- Clearing vegetation from portions of the inundated reservoir area
- Constructing the dam raise, appurtenant structures, reservoir area dikes, and railroad embankments
- Relocating roadways, bridges, recreation facilities, utilities, and miscellaneous minor infrastructure
- Augmenting spawning gravel in the upper Sacramento River
- Restoring riparian, floodplain, and side channel habitat
- Enhancing Shasta Lake and tributary shoreline

Construction activities for CP5 are described in detail in the Engineering Summary Appendix.

Operations and Maintenance for CP5

Operations under CP5 are governed by the same regulatory constraints as described for CP1. Similar to CP1, the additional storage would be retained to increase water supply reliability and to expand the cold-water pool in Shasta Reservoir for fisheries benefits. Similar to CP1, Shasta Dam operational guidelines would continue unchanged, except during dry years and critical years, when 150,000 acre-feet and 75,000 acre-feet, respectively, of the 634,000 acre-feet increased storage capacity in Shasta Reservoir would be operated primarily to provide increased M&I deliveries. Operations targeting increased M&I deliveries were based on existing and anticipated future demands, operational priorities, and facilities of the SWP. For CP5, existing water quality and temperature requirements would typically be met in most years; therefore, additional water in storage would be released primarily for water supply purposes. Accordingly, minimal increases in flow would be expected in months when Delta exports were constrained, or when flow was not usable for water supply purposes.

In comparison to current operations, CP5 would store some additional flows behind Shasta Dam during periods when downstream needs would have already been met, but flows would have been released because of storage limitations. The resulting increase in storage would be released downstream when there were opportunities for beneficial use of the water, either to meet water supply reliability demands or to improve Reclamation's abilities to meet its environmental objectives. The additional water in storage would also expand the cold-water pool and increase end-of-September carryover storage in Shasta Reservoir, increasing the ability of Shasta Dam to improve water temperatures for anadromous fish in the upper Sacramento River.

Conversely, if water in storage were insufficient to meet all of the project purposes, the first increment to be reduced would be deliveries to water service contractors. Releases from Shasta Dam under CP5 would typically increase in the summer months, corresponding with the periods of greatest agricultural demands. Similarly, releases would be reduced in the winter months, when the increased storage space could be used to capture additional runoff rather than releasing water to the downstream river, as would occur with Shasta Reservoir's current operations.

Maintenance of facilities related to the proposed dam and reservoir enlargement would be similar to maintenance activities currently conducted at Shasta Dam and Reservoir.

Operation of pumping facilities downstream from Shasta Dam would vary slightly from current operations and would result in higher costs. In addition, Reclamation would provide in-kind power to offset reduced generation at Pit 7 Dam and related facilities.

Potential Primary Effects from CP5

Following is a summary of potential environmental consequences of CP5. Anticipated inundation, construction, cultural, and relocation impacts associated with CP5 are similar to CP3, CP4, and CP4A as summarized above. Proposed mitigation measures to address potential adverse impacts of CP5 are summarized in Table 5-9. As mentioned, a detailed discussion of potential effects and proposed mitigation measures associated with raising Shasta Dam by 18.5 feet are included in Chapters 4 through 25 of the EIS.

Shasta Lake Area As with the other comprehensive plans, the primary long-term effects of CP5 would be due to the increased water surface elevations and inundation area. Anticipated effects of increased water surface elevations under CP5 are similar to CP3. As with the above plan, raising the full pool of the lake would cause direct effects due to higher water levels, and/or indirect impacts related to facility access modifications and relocations.

CP5 includes modifying two bridges and replacing six other bridges, inundating a number of small segments of existing paved and nonpaved roads, and relocating a number of potable water facilities, wastewater facilities, gas and petroleum facilities, and power distribution and telecommunications facilities. A number of recreation facilities would also be impacted, including campgrounds, marinas, resorts, boat ramps, day use areas, and trails. Approximately 30 segments of roadway would be relocated, including portions of Lakeshore Drive, Fenders Ferry Road, Gilman Road, and Silverthorn Road. Embankments would be constructed to protect I-5 at Lakeshore and the UPRR at Bridge Bay. Any potential real estate acquisitions or necessary relocations of displaced parties would be accomplished under Public Law 91-646.

With CP5, Shasta Reservoir would fill to the new full pool storage capacity of 5.19 MAF at a frequency similar to without-project conditions. On the basis of water operations modeling (CalSim-II), Shasta Reservoir fills to 80 percent of its current capacity in about 81 percent of the years over the 82-year period of analysis of the CalSim-II model. Included in Figure 5-5 is an exceedence probability relationship of maximum annual storage in Shasta Lake for this and other dam raises. Under CP5, Shasta Reservoir would also fill to 80 percent of the new capacity in about 72 percent of the years. Accordingly, the annual operations in the reservoir would generally mirror existing operations, except the water surface in the lake would be about 18.5 feet higher. The primary difference in the reservoir area would be that during extended drought periods, the reservoir would be drawn down to without-project minimum levels. Figure 5-26 shows the changes from without-project conditions for CP5 for a representative period of 1972 through 2003.

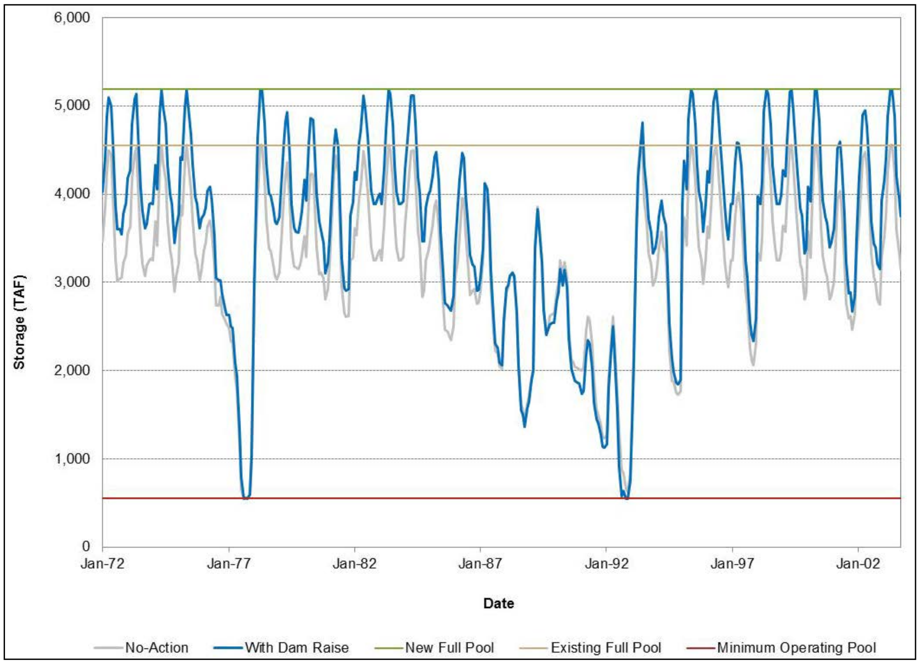


Figure 5-26. Simulated Shasta Reservoir Storage from 1972 to 2003 for the No-Action Alternative and CP5

The increased area of inundation for this plan is about 2,600 acres. As with the previous plans, much of the vegetation in the enlarged drawdown zone on steeper lands would be removed during construction. In addition, some vegetation in the expanded drawdown zone would eventually be lost over time. However, it is expected that significant amounts of vegetation could remain on the lower slopes because of the infrequent inundation. The lower reaches of tributaries to Shasta Lake also would experience increased inundation.

As shown in Figure 5-9, raising Shasta Dam 18.5 feet would result in inundating an additional 3,550 linear feet (about 27 acres) of the lower McCloud River. This represents about 3 percent of the 24-mile reach of river between the McCloud Bridge and the McCloud Dam, which controls flows on the river.

Although it is believed that recreation use would generally improve under this plan because of a larger lake surface area, water in the lake would be drawn down to existing conditions during the late fall and winter periods of some dry years, representing a drawdown 20.5 feet greater than under existing conditions. During these periods, the drawdown zone could increase by about 50 linear feet. In addition, clearances for boat traffic under the Pit River Bridge would be restricted to the north end of the bridge during periods of high reservoir levels (at or near full pool). This condition would typically occur in the late spring (May to June) in about 1 out of 3 years, and could last several days to 1 or 2 weeks. Figure 5-18 illustrates that the minimum clearance at the new full pool would be about 14 feet between Piers 6 and 7. This could impact boating on the lake, as some houseboats exceed 16 feet in height. Since houseboating is a major recreational experience on Shasta Lake, especially around Memorial Day, restrictions on large boat traffic under the Pit River Bridge during maximum pool levels could adversely impact lake area boat rentals, marinas, and other recreation-dependent businesses.

Significant effects to cultural resources due to enlarging Shasta Dam and Reservoir for CP5 include: (1) the disturbance or destruction of archaeological and historic resources due to construction or inundation and (2) inundation of traditional cultural properties and sacred sites. Sensitivity and archival studies estimate that for CP5, approximately 391 and 529 historic sites are within the inundation zone and fluctuation, respectively. Effects to traditional cultural properties and sacred sites under CP5 would be similar to CP1.

Additional long-term effects on biological resources associated with the relocation of reservoir area infrastructure are anticipated. Short-term, construction-related impacts are also anticipated in the primary study area.

Upper Sacramento River As with the previous plan, potential effects on flow and stages of the upper Sacramento River from this and other comprehensive plans would be minimal. Figures 5-27, 5-28, and 5-29 show CalSim-II simulated Sacramento River flows below Keswick Dam, RBPP, and Stony Creek, respectively, under wet, above- and below-normal, and dry and critical year conditions for the No-Action Alternative compared to CP5. During most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. Also, flows and stages would increase slightly from June through November. Although small, this increase would be most pronounced during dry periods as more water is released from Shasta Dam for water supply reliability purposes. During dry periods, however, there are few to no changes in water flows or changes during the winter and spring periods. All potential noticeable changes in flows and stages would diminish rapidly downstream from the RBPP.

Similar to other comprehensive plans, changes in river flow and stages may impact geomorphic conditions, existing riparian vegetation, and wildlife resources of the upper Sacramento River. As mentioned above, the changes in temperature and flows are expected to have a beneficial effect on anadromous fish resources. A possibility exists, however, that by benefiting anadromous fish, a slightly altered temperature and flow regime may adversely impact warm-water species in the Sacramento River. This effect is not expected to be significant.

No effects on cultural resources are expected to occur in the upper Sacramento River region.

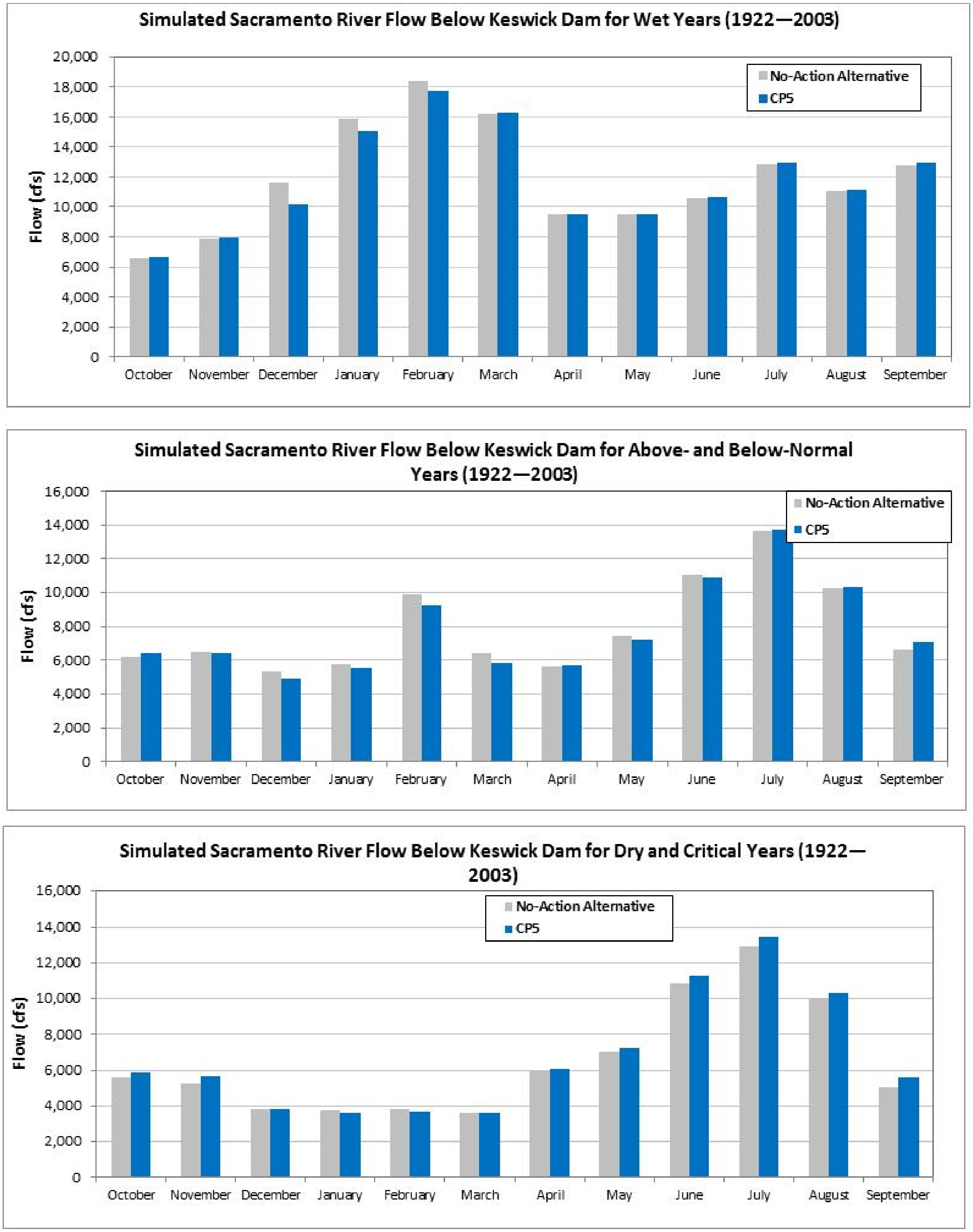


Figure 5-27. Simulated Sacramento River Flow Below Keswick Dam in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action and CP5

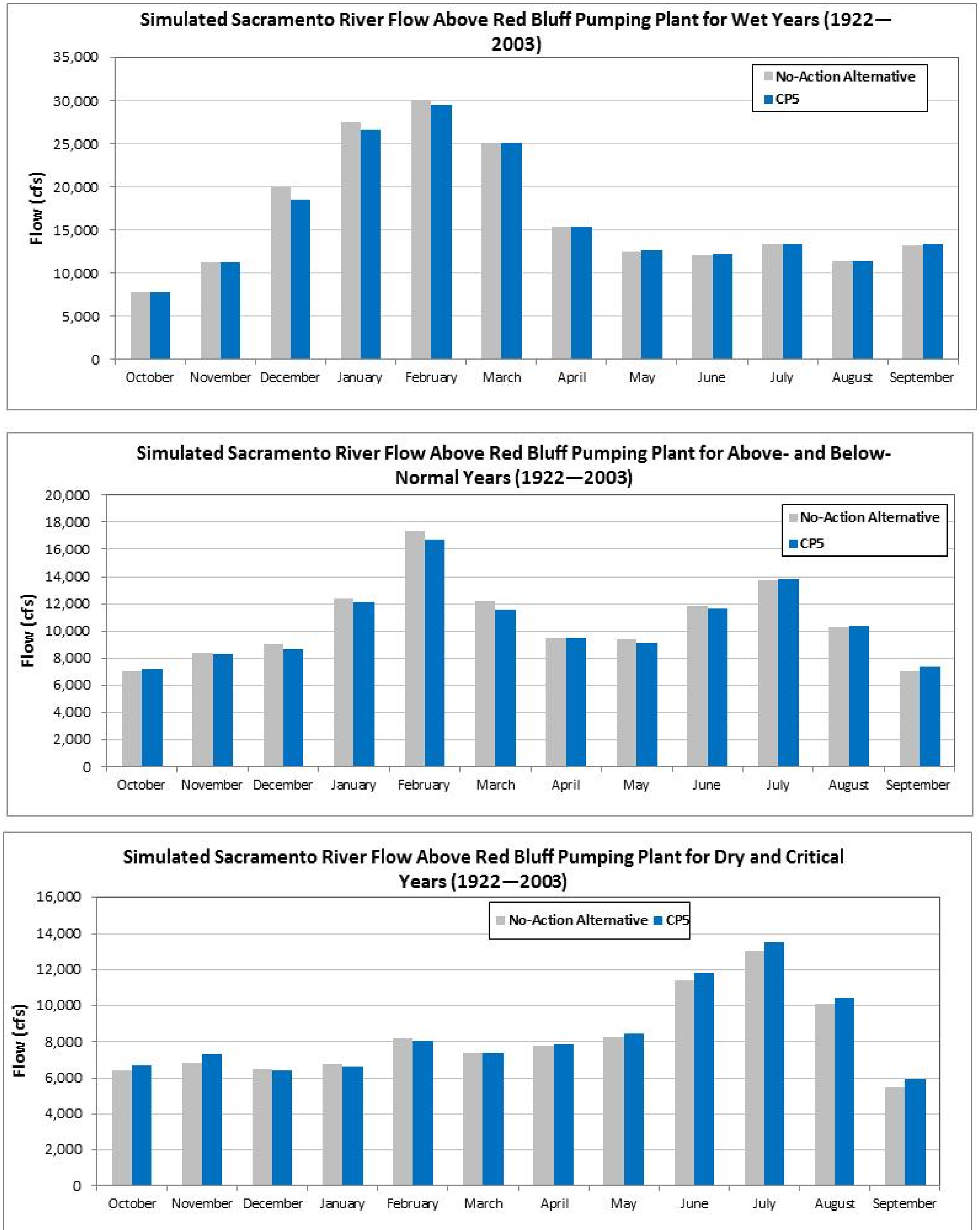


Figure 5-28. Simulated Sacramento River Flow Below Red Bluff Pumping Plant in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action and CP5

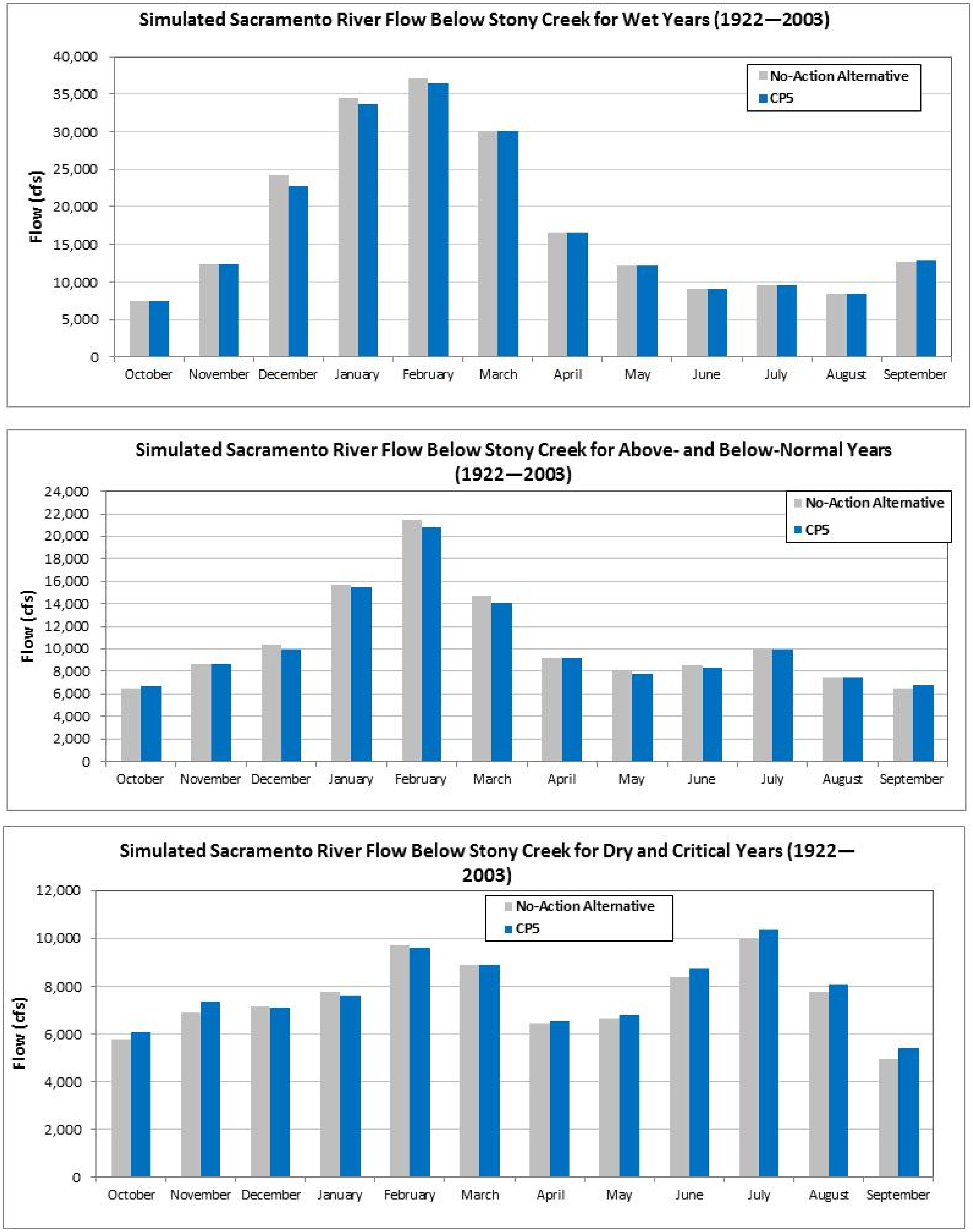


Figure 5-29. Simulated Sacramento River Flow Below Stony Creek in Wet, Above- and Below-Normal, and Dry and Critical Years for No-Action and CP5

Some potential exists for impacting existing habitat at upper Sacramento River restoration sites, but these impacts would likely result from converting present land use back to a more typical riverine environment.

Potential Benefits and Costs of Comprehensive Plans

The following sections summarize the estimated costs and potential benefits of SLWRI EIS comprehensive plans.

Estimated Costs for Comprehensive Plans

Table 5-10 summarizes estimated construction and average annual costs for each of the Comprehensive Plans. These costs were developed to a feasibility level in April 2012 dollars. More detailed information regarding estimated construction costs for the comprehensive plans is included in the Engineering Summary Appendix. Field cost is an estimate of capital costs of a feature from award to construction closeout. Construction cost is the sum of the feature field costs plus non-contract costs. Non-contract costs refer to costs of work or services provided in support of feature construction, and other work that can be attributed to the feature as a whole, which include facilitating services, investigations, design and specifications, construction management, environmental compliance, and archeological considerations. Total capital cost is the sum of the construction costs and IDC, which is interest that accrues on a loan that finances construction.

Total annual costs were estimated using interest and amortization of the capital cost over 100 years and at the current Federal discount rate of 4 percent. Estimated annual O&M costs are also included, which is estimated at 0.2 percent of the field cost plus the costs associated with the increase in CVP/SWP system pumping energy use.

Summary of Potential Benefits of Comprehensive Plans

Major potential benefits of the comprehensive plans, in relation to contributions to the SLWRI planning objectives, are summarized in Table 5-11. Quantified benefits in Table 5-11 are based on modeling efforts that are described in several locations of the EIS, including Chapter 6, “Hydrology, Hydraulics, and Water Management;” Chapter 11, “Fisheries and Aquatic Resources;” Chapter 23, “Power and Energy;” and the Modeling Appendix.

Table 5-10. Estimated Construction and Average Annual Costs[1]

Item	CP1 6.5 Feet ($ millions)	CP2 12.5 Feet ($ millions)	CP3 18.5 Feet ($ millions)	CP4 18.5 Feet ($ millions)	CP4A 18.5 Feet ($ millions)	CP5 18.5 Feet ($ millions)
Construction Costs						
Field Costs						
Relocations						
Vehicular Bridges	$34	$34	$54	$54	$54	$54
Doney Creek Railroad Bridge	$56	$56	$56	$56	$56	$56
Sacramento River Railroad Bridge, Second Crossing	$116	$116	$116	$116	$116	$116
Pit River Bridge Modifications	$17	$23	$31	$31	$31	$31
Railroad Realignment	$8.2	$8.2	$8.2	$8.2	$8.2	$8.2
Roads	$17	$26	$37	$37	$37	$37
Local Utilities	$24	$24	$30	$30	$30	$30
Transmission Lines	$19	$19	$19	$19	$19	$19
Buildings/Facilities – Recreation	$133	$150	$166	$166	$166	$166
Dams and Reservoirs						
Main Dam	$54	$64	$76	$76	$76	$76
Outlet Works	$27	$27	$27	$27	$27	$27
Spillway	$126	$131	$131	$131	$131	$131
Temperature Control Device	$28	$30	$31	$31	$31	$31
Powerhouse and Penstocks	$1.3	$1.3	$1.3	$1.3	$1.3	$1.3
Right Wing Dam	$4.6	$5.7	$6.9	$6.9	$6.9	$6.9
Left Wing Dam	$13	$18	$26	$26	$26	$26
Visitor Center	$8.4	$8.8	$9.1	$9.1	$9.1	$9.1
Dikes	$14	$16	$27	$27	$27	$27
Reservoir Clearing	$4.5	$7.2	$21	$21	$21	$21
Pit 7 Dam and Powerhouse Modifications	$8.2	$8.2	$8.2	$8.2	$8.2	$8.2
Environmental Restoration	-	-	-	$6.2	$6.2	$18.2
Recreation Enhancement	-	-	-	-	-	$1.3
Total Field Costs	$713	$773	$881	$887	$887	$901
Planning, Engineering, Design, and Construction Management	$160	$174	$198	$200	$200	$203
Lands	$30	$47	$69	$70	$70	$70
Environmental Mitigation	$71	$77	$88	$88	$88	$88
Cultural Resource Mitigation	$14	$15	$18	$18	$18	$18
Water Use Efficiency Actions	$1.6	$2.6	$3.1	$1.6	$2.6	$3.8
Total Construction Cost	**$990**	**$1,089**	**$1,257**	**$1,264**	**$1,265**	**$1,283**
Interest During Construction[1]	**$83**	**$91**	**$105**	**$105**	**$105**	**$108**
Total Capital Cost	**$1,073**	**$1,180**	**$1,362**	**$1,370**	**$1,371**	**$1,391**
Interest and Amortization	**$39**	**$43**	**$49**	**$50**	**$50**	$50
Operations and Maintenance	**$6.3**	**$8.5**	**$4.6**	**$7.5**	**$9.4**	$10.7
Total Annual Cost	**$45**	**$51**	**$54**	**$57**	**$59**	**$61**

Notes:

1 For SLWRI comprehensive plans, IDC was applied over the time until the debt is to begin being served, which was estimated at 4 years for all of the comprehensive plans, at the current Federal discount rate of 3.5 percent.

2 Cost estimate is feasibility-level in January 2014 dollars, and subject to change in the future. Escalation from published price level to notice to proceed is excluded. Estimates may include discrepancies due to rounding. For appropriate use and terminology, see Reclamation Manual, Directives and Standards FAC; 09-01, 09-02 and 09-03. Detailed information regarding cost estimates and assumptions for the Comprehensive Plans is included in the Engineering Summary Appendix.

Table 5-11. Summary of Potential Features and Benefits of SLWRI Comprehensive Plans (Compared to No-Action Alternative)

Item	CP1	CP2	CP3	CP4	CP4A	CP5
Shasta Dam Raise (feet)	6.5	12.5	18.5	18.5	18.5	18.5
Total Increased Storage (TAF)	256	443	634	634	634	634
Benefits						
Increase Anadromous Fish Survival						
Dedicated Storage (TAF)	-	-	-	378	191	-
Production Increase (thousand fish)[1]	61	379	207	813	710	378
Spawning Gravel Augmentation (tons)[2]				10,000	10,000	10,000
Side Channel Rearing Habitat Restoration				Yes	Yes	Yes
Increase Water Supply Reliability						
Total Increased Dry and Critical Year Water Supplies (TAF/year)[3]	47.3	77.8	63.1	47.3	77.8	113.5
Increased NOD Dry and Critical Year Water Supplies (TAF/year)3	4.5	10.7	35.2	4.5	10.7	25.2
Increased SOD Dry and Critical Year Water Supplies (TAF/year)3	42.7	67.1	28.0	42.7	67.1	88.3
Increased Water Use Efficiency Funding	Yes	Yes	Yes	Yes	Yes	Yes
Increased Emergency Water Supply Response Capability	Yes	Yes	Yes	Yes	Yes	Yes
Reduce Flood Damage						
Increased Reservoir Storage Capacity	Yes	Yes	Yes	Yes	Yes	Yes
Additional Hydropower Generation						
Increased Hydropower Generation (GWh/year)[4]	52 - 54	87 - 90	86 - 90	127 - 133	125 - 130	112 - 117
Conserve, Restore, and Enhance Ecosystem Resources						
Shoreline Enhancement (acres)	-	-	-	-	-	130
Tributary Aquatic Habitat Enhancement (miles)[5]	-	-	-	-	-	6
Riparian, Floodplain, and Side Channel Restoration Habitat	-	-	-	Yes	Yes	Yes
Increased Ability to Meet Flow and Temperature Requirements Along Upper Sacramento River	Yes	Yes	Yes	Yes	Yes	Yes
Improve Water Quality						
Improved Delta Water Quality	Yes	Yes	Yes	Yes	Yes	Yes
Increased Delta Emergency Response Capability	Yes	Yes	Yes	Yes	Yes	Yes
Increase Recreation						
Recreation (user days, thousands)[6]	85 - 89	116 - 134	201 - 205	307 - 370	246 - 259	142 - 175
Modernization of Recreation Facilities	Yes	Yes	Yes	Yes	Yes	Yes

Notes:

[1] Numbers were derived from SALMOD and represent an index of production increase, based on the estimated average annual increase in juvenile Chinook salmon surviving to migrate downstream from the RBPP.

[2] Average amount per year for 10-year period.

[3] Total drought period reliability for Central Valley Project and State Water Project deliveries. Does not reflect benefits related to water use efficiency actions included in all comprehensive plans.

[4] Annual increases in hydropower generation were estimated using two methodologies – at load center (accounting for transmission losses) and at-plant (no transmission losses). To provide a more conservative estimate of potential hydropower benefits, load center generation values were used to estimate potential benefits of increased hydropower generation under comprehensive plans. However, increased generation values reported in Chapter 23 of this EIS are based on at-plant generation values to capture the largest potential effects from changes in hydropower generation and pumping.

[5] Tributary aquatic enhancement provides for the connectivity of native fish species and other aquatic organisms between Shasta Lake and its tributaries. Estimates of benefits reflect only connectivity with perennial streams and do not reflect additional miles of connectivity with intermittent streams.

[6] Annual recreation visitor user days were estimated using two methodologies. The minimum user day value was used to estimate potential recreation benefits to provide a more conservative estimate of the potential benefits of increased recreation under comprehensive plans. However, the maximum user value was used for direct and indirect effects evaluations in each resource area chapter to capture the largest potential effects from increased visitation. These values do not account for increased visitation due to modernization of recreation facilities associated with all comprehensive plans. For more detailed information related to estimated recreation user days, please see Chapter 10, “Recreational Visitation,” of the Modeling Appendix.

Table 5-11. Summary of Potential Features and Benefits of SLWRI Comprehensive Plans (Compared to No-Action Alternative) (contd.)

Key:
- = not applicable
CP = comprehensive plan
Delta = Sacramento-San Joaquin Delta
GWh/year = gigawatt-hours per year
NOD = north of Delta
SOD = south of Delta
SLWRI = Shasta Lake Water Resources Investigation
RBPP = Red Bluff Pumping Plant
TAF = thousand acre feet

Preferred Alternative and Rationale for Selection

NEPA guidelines (Title 40, Code of Federal Regulations (CFR) Section 1502.14(e) (40 CFR 1502.14(e))) require that the DEIS “identify the agency's preferred alternative or alternatives, if one or more exists, in the draft statement and identify such alternative in the final statement unless another law prohibits the expression of such a preference.” The preferred alternative is the alternative which is believed to fulfill Reclamation’s statutory mission and responsibilities, giving consideration to economic, environmental, technical and other factors (CEQ 1981).

A plan recommending Federal action should be the plan that best addresses the targeted water resources problems considering public benefits relative to costs. The basis for selecting a plan for recommendation is to be fully reported and documented, including the criteria and considerations used in selecting a recommended course of action by the Federal Government. It is recognized that most of the activities pursued by the Federal Government will require assessing trade-offs by decision makers and that in many cases, the final decision will require judgment regarding the appropriate extent of monetized and nonmonetized effects.

The needed rationale to support Federal investment in water resources projects is described in the 2009 Council on Environmental Quality’s Draft *Proposed National Objectives, Principles, and Standards for Water and Related Resources Implementation Studies (CEQ 2009)*:

> *The presentations shall summarize and explain the decision rationale leading from the identification of need through the recommendation of a specific alternative. This shall include the steps, basic assumptions, analysis methods and results, criteria and results of various screenings and selections of alternatives, peer review proceedings and results, and the supporting reasons for other decisions necessary to execute the planning process. The information shall enable the public to understand the decision rationale, confirm the supporting analyses and findings, and develop their own fully-informed opinions and/or*

> *decisions regarding the validity of the study and its recommendations.*
>
> *Opportunities shall be provided for public reaction and input prior to key study decisions, particularly the tentative and final selection of recommended plans. The above information shall be presented in a decision document or documents, and made available to the public in draft and final forms. The document(s) shall demonstrate compliance with the National Environmental Policy Act (NEPA) and other pertinent Federal statutes and authorities.*

NEPA CEQ Regulations requires the identification of the alternative or alternatives that are environmentally preferable in the Record of Decision (ROD) (40 CFR 1505.2(b)). The environmentally preferable alternative generally refers to the alternative that would result in the fewest adverse effects to the biological and physical environment. It is also the alternative that would best protect, preserve, and enhance historic, cultural, and natural resources. Although this environmentally preferable alternative must be identified in the ROD, it need not be selected for implementation. For the purposes of NEPA, an environmentally preferable alternative will be identified in the ROD associated with this EIS.

The preferred alternative has been identified in the Final EIS in consideration of public, stakeholder, and agency comments on the DEIS.

Preferred Alternative

Each of the action alternatives – CP1, CP2, CP3, CP4, CP4A, and CP5 – includes enlarging Shasta Dam and Reservoir and a variety of management measures to address, in varying degrees, all of the project objectives. The major benefits of the action alternatives are summarized in Table 2-24 of the Final EIS, and the impacts and mitigation measures are summarized in Table S-3 of the EIS Executive Summary. The cost estimates are presented in the Engineering Summary Appendix, Attachment 1, “Cost Estimates for Comprehensive Plans.”

In the action alternatives, dam raises of three different heights were evaluated – 6.5 feet, 12.5 feet, and 18.5 feet. While all action alternatives provide primary and secondary project benefits (to varying degrees), the overall benefits of an 18.5-foot raise (CP3, CP4, CP4A, or CP5) were found to be greater than those of either a 6.5-foot raise (CP1) or 12.5-foot raise (CP2). Therefore, only the 18.5-foot raise action alternatives were retained as possibilities for the preferred alternative. For example, the additional reservoir storage would increase from 256,000 acre-feet with the 6.5-foot raise to 634,000 acre-feet with the 18.5-foot raise – nearly 2.5 times the additional reservoir storage of the 6.5-foot raise for between 15-25 percent greater construction costs. This additional reservoir storage space would support both water supply reliability and fisheries objectives.

Reservoir operations and the resulting benefits were the differentiators amongst the 18.5-foot raise action alternatives (CP3, CP4, CP4A, or CP5). For example, CP3 would maximize agricultural water supply reliability, but would the least beneficial to fisheries of the 18.5-foot raises. CP4 would provide the best opportunity to address anadromous fish survival in the upper Sacramento River; however, CP4 would provide the lowest benefits to water supply reliability.

Below is a summary of each action alternative eliminated for consideration as the preferred alternative.

- CP1, formulated to address both anadromous fish survival and water supply reliability, would result in the lowest benefits of all of the action alternatives. Greater project benefits could be recognized with higher dam raises for relatively low increases in costs. Therefore, CP1 was eliminated for consideration as the preferred alternative

- CP2, formulated to address both anadromous fish survival and water supply reliability, would have relatively low benefits when compared to the other action alternatives. Greater project benefits could be recognized with higher dam raises for relatively low increases in costs. Therefore, CP2 was eliminated for consideration as the preferred alternative.

- CP3, formulated to address both agricultural water supply reliability and anadromous fish survival, would greatly increase agricultural water supply reliability. However, CP3 would have no M&I water supply benefits and very low anadromous fish survival benefits when compared to the other 18.5-foot raises. Therefore, CP3 was eliminated for consideration as the preferred alternative.

- CP5, formulated as a combination plan focusing on all objectives, would greatly increase water supply reliability. However, CP5 would have relatively low increased anadromous fish survival benefits in comparison with all other 18.5-foot raises. Therefore, CP5 was eliminated for consideration as the preferred alternative.

- CP4, formulated to focus on anadromous fish survival while water supply reliability. Although CP4A would have the highest increase in anadromous fish survival of all of the alternatives, CP4A would have the lowest water supply reliability compared to all of considered alternatives (equal to CP1). CP4 would not best meet both of the primary objectives; water supply reliability would be compromised for increased anadromous fish survival. Therefore, CP4 was eliminated for consideration as the preferred alternative.

CP4A would best balance and meet both of the primary objectives. CP4A, formulated to address both anadromous fish survival and water supply reliability, would have the second highest water supply reliability of all alternatives (equal to CP2) and the second highest increase in anadromous fish survival of all of the alternatives. CP4A would have the ability to meet the secondary project objectives, which were considered to the extent possible through pursuit of the primary project objectives. Secondary objectives include ecosystem enhancement, flood damage reduction, improved Delta water quality, increased hydropower generation and increased recreation. As an 18.5-foot raise, CP4A would best maximize benefits relative to costs. For these reasons, CP4A is the preferred alternative

Chapter 6
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